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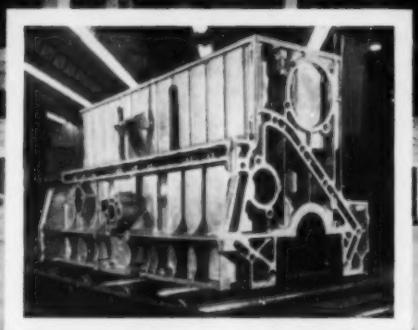
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · OCTOBER 10, 1960



Rambler Aluminum engine block die-cast automatically... see page 3

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VIBRATION RESISTANCE OF THREAD-LOCKING DEVICES ..... page 58
THE FLEXGAGE—A DOUBLEDECK RESISTANCE STRAIN GAGE ..... page 55

Belly-deep in abrasives!

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

October 10, 1960 Vol. 31, No. 42

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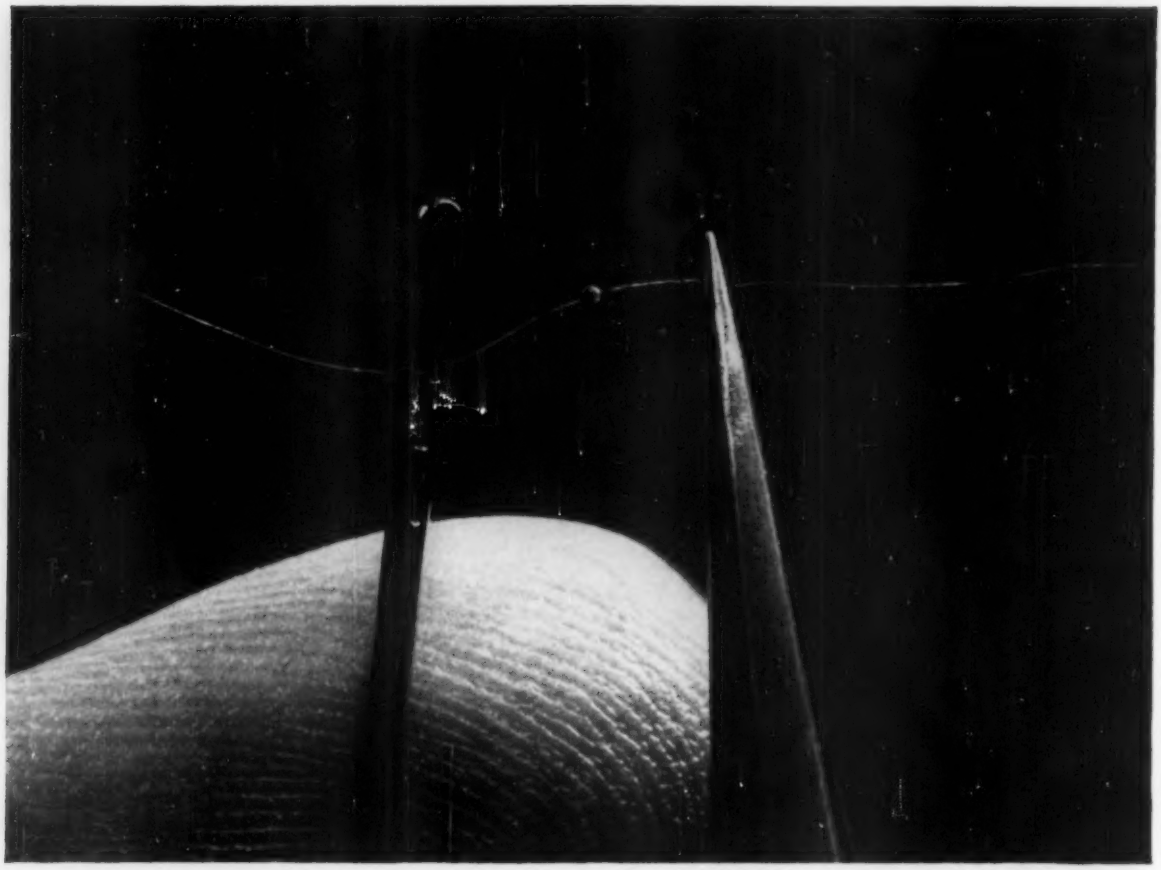

Needle's eye reveals relative size of the thermistor, a tiny bead of Nickel oxide and other materials, used to measure temperatures in and beyond the earth's thin envelope of atmosphere. Made by Gulton Industries, Inc., the thermistor now serves in more than a dozen different missiles and satellites.

"Space thermometer" goes thru needle's eye

Meet the bead thermistor, member of a family of electronic devices now going into everything from midget radios to giant computers and missiles.

This particular thermistor measures temperatures in space — temperatures ranging from 572°F all the way down to 76° below zero Fahrenheit.

You can hardly see the bead with your naked eye. Although it's only *a hundredth of an inch* in diameter, and the lead wires are a mere thousandth of an inch thick, the thermistor is an extremely stable and rugged device, accurate to within a fraction of a degree Fahrenheit.

Made of Nickel oxide and other materials, the thermistor is a space-traveler in many of today's missiles and satellites. It reliably reports on gradients of temperature within the earth's thin atmospheric shield and in outer space. At the same time, it helps record the temperature changes in the missile's skin and its interior.

What is a thermistor? Its name, which comes from THERMal resISTOR, begins to explain. Temperature changes as small as 1/50 of a degree produce a measurable change in the electrical resistance of the pellet. The resulting increase or decrease in circuit current can then be used directly, as a signal, or can be recorded in the form of temperature readings.

Originally developed by Bell Telephone Laboratories for communications equipment, thermistors are now widely used where a tiny, precise, and dependable thermometer is needed: in medical research, in over-load switches to protect electric motors, and in shipment of perishable foodstuffs, for example.

The role of Nickel in the thermistor is only one example of the remarkable versatility of this element.

Be sure to investigate Nickel and Nickel compounds whenever you are faced with a problem calling for unusual electrical or electronic properties... in fact, for *any* unusual metal problem. And don't hesitate to call on us for technical data to help you solve your material-selection problems.

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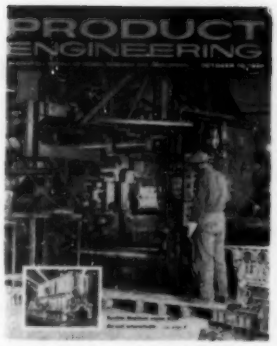
INTERESTING TO NOTE



On our cover—Die-cast aluminum engine blocks being produced for American Motors Corp by the Doehler-Jarvis Div of National Lead Co. The engine block weighs 67 lb, of which 14 lb are cast iron liners produced by centrifugal casting. Cast-in-place liners are chemically and mechanically bonded to aluminum. Design details of engine, page 62.

Aluminum automobile engines have been finding increased application in European cars (Jaguar, BMW, Porsche, Citroen, Lancia, Fiat, etc.) and some American manufacturers have begun switching over, too (Rambler, Corvair). In 1922, the H H Franklin Co manufactured an engine using an aluminum crankcase, pistons and connecting rods. Previously the Europeans had led the way with the Dion Bouton aircooled engine, with an aluminum crankcase, in 1898.

Logs for Everything—Even Logs

It was only natural, soon after the Scottish mathematician John Napier developed the first table of logarithms, that somebody would correlate them on a sliding scale. That somebody was the English clergyman, William Oughtred, who taught mathematics as a hobby. In 1632, he published a paper entitled "Circles of Proportions" in which he described and pictured a series of circles containing logarithms. By rotating the circles, certain log problems could be quickly solved. The following year he developed the rectangular sliderule. His invention was an immediate boon to astronomers; they welcomed it the way electronic computers have been received in our day. Problems that took days to perform could be solved in hours with the sliderule.

Although the most common rule used by engineers today is the straight 10-incher (actually 25 centimeters long or $9\frac{7}{8}$ in.), there are at least several hundred varieties of the sliderule adopted for other than engineering applications. Recently a special sliderule for housewives was placed on the market—it saves the man of the house from answering such questions as, "What's a cup and a half divided by three?" There are sliderules for every make of airplane, telling the pilot his safe weight loads; each artillery unit in the army has a special rule to compute the trajectory of shells; there are even rules to assist missile interception calculations. In 1868, a patent was granted for a circular rule which is probably the largest ever built—with a diameter of 16 feet. It was used for making saw-log calculations needed in the timber industry.

Engineers and scientists still buy more sliderules than any other group. There are about 5 million sliderules in use in this country alone, of which more than three hundred are designed for solving problems other than those involving logarithms. For those interested in some time-saving tips on sliderule problems see the article on page 65.

continued, next page

PRODUCT ENGINEERING

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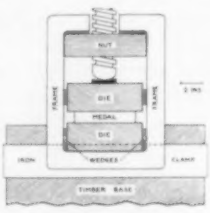
INTERESTING TO NOTE continued

The Cellini Press

Fasteners during the 16th century consisted mainly of rivets, buckles, screws and locks (for more on fasteners today, see p 58). With these, the armorer was able to design the finest steel "suits." However, one of these valuable fastening principles, the screw, was being adopted for other purposes. The great Italian goldsmith, Benvenuto Cellini, designed an efficient screw press to strike brass medals for Pope Clement VII. His device broke from the traditional method of making these medals—which was casting.

Cellini designed a set of dies, placed them in a container (see illustration) and was able to strike about one hundred coins for the Pope. It is interesting that little came of the Cellini screw-press. Even though it was able to turn out 20 coins for every one cast or pounded out by a hammer and die, it was totally rejected by those responsible for the minting of coins. The reason is undoubtedly twofold. The capital expenditure required to install a screwpress was heavy when compared to ordinary hand-coiner's equipment. Secondly, the speed and efficiency of Cellini's press could easily have put the many individual minters out of business. Although there were no unions as we know them, guilds undoubtedly resisted any introduction of a "labor-saving" press in the mints. As a result, the Cellini press remains one of his least known achievements. However, the same screw principle Cellini used to mint coins was adopted by the guardians of the medieval torture chamber in the form of the thumb screw.

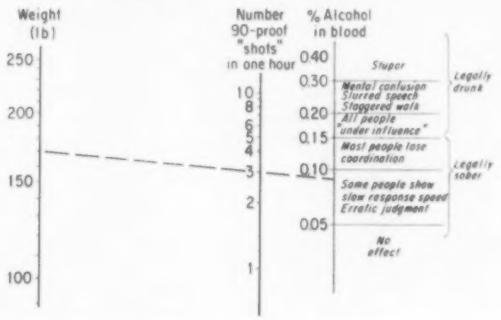


—Benedict A. Leerburger Jr

SIDELIGHT

Nomographs are habit-forming. Maybe you've seen an "addict"—an engineer who spends all his free time hunched over sliderule and graph paper. Probably he began innocently enough; one day he thought he could save time by constructing a nomograph to simplify a much-used equation. Now he can't stop.

The editor of the article on page 66 was carried away so far that he left what we like to think of as the usual realm of the engineer. The result is shown below. Anyone know of a Nomographics' Anonymous?



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. . . **How the Resistance Transducers Compare**

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. . . **Designing with Sintered Beryllia**

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. . . **Try Pneumatics for Hi-temp Systems**

Two researchers at Battelle Memorial Institute report on a hypothetical hot-gas servovalve—to determine how air responds in fluid systems at high temperatures.

. . . **When Helical Gears Get You Out of Tight Spots**

Their adaptability can overcome many difficulties in gear-train design that normally call for complicated, expensive measures.

. . . **How Much Torsion for Off-center Loads?**

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DEVELOPMENTS TO WATCH . . .

Aluminum wool improves molded plastics

By incorporating aluminum "wool" in exothermic plastic materials (in this case, epoxies and polyesters that generate heat as they are cured), better moldings can be made, says Croxton & Garry Ltd, of Surrey, England.

The wool aids heat dissipation; and, if enough of it is used, thermally conductive products can be produced. Aluminum is superior to steel wool and to metal powders, C & G says, because it's lighter in weight, less brittle, and shows improved thermal conductivity. Furthermore, material containing aluminum wool is easier to machine. Addition of mineral fillers further improves machinability and provides controlled thermal expansion.

In the amounts used for heat dissipation (70 to 80 parts by weight) the wool does not markedly increase electrical conductivity. C & G is working on applications of this type; but says they will require development of a special technique for applying the wool, and may require a special type of wool as well.

New bonding techniques for zirconium and aluminum

A new brazing alloy for zirconium and a method for joining aluminum to stainless steel without the use of flux are reported by AEC researchers this month.

The alloy, suitable for bonding to ceramics as well as other metals, is a combination of zirconium with 6 to 9% by weight of nickel, 6 to 9% of chromium, molybdenum, or tungsten, and up to 7½% iron. The basic composition has been patented (#2,932,887) and is available for royalty-free use.

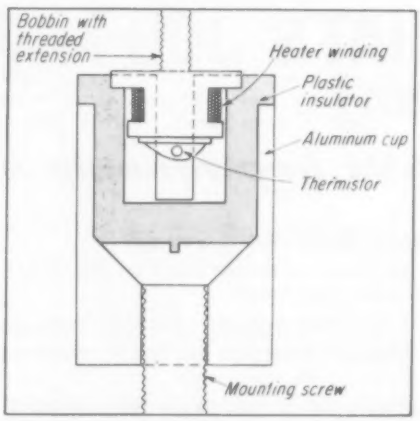
The process for bonding aluminum to stainless involves tinning both surfaces and then sweating the two together. For coating the aluminum, a 1% silver–1% lead alloy is used; for the stainless steel, 50% lead–50% tin. This process too, has been patented (#2,937,438) and is being released for royalty-free, nonexclusive use. Information on both may be obtained from the Office of the General Counsel, USAEC, Washington 25, DC.

Thermal time-delay developed in Australia

For on-off temperature and humidity controllers and other applications involving fairly long time-constants, the Commonwealth Scientific and Industrial Research Organization is developing a simple, effective dual transducer system.

The basic unit is a small copper bobbin on which a heater is wound and to which a thermistor is attached (see diagram). They are mounted in pairs on an aluminum frame and connected in a bridge circuit (to minimize effects of ambient temperature) to a printed circuit board.

Time constants can be varied by fitting suitable thermal masses (aluminum or copper weights) to the bobbin extension, and output characteristics by varying the percentage of the input signal fed to each unit.



TRANSDUCER UNIT consists of bobbin and heater, mounted in plastic sleeve. Aluminum cup provides path for heat dissipation.

Unloaded units, says CSIR have a time constant of about 35 sec; but this may be extended to 10 min. using unlagged weights; and to over 30 min. if plastic-capped weights are used. The "caps" are foamed-plastic insulators.

Plans are being made for commercial production in Australia, and the design is available for licensing by US manufacturers.

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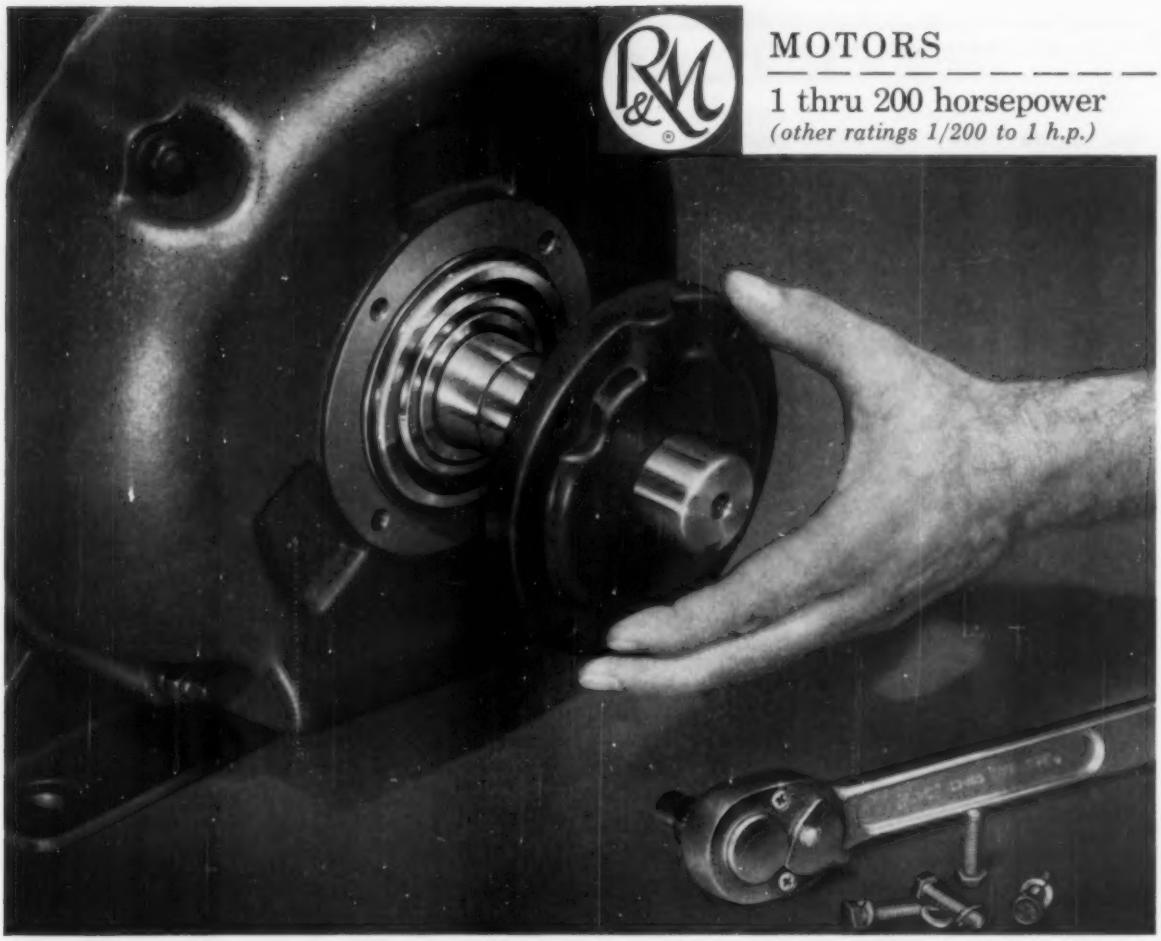

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Easily removable bearing caps are only one of R&M's many desirable design features. Double width bearing races have extra-large grease capacity . . . Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . end heads offer full-height protection . . . dual-sweep ventilation assures efficient cooling. For details, write today for Bulletin 520 PRE

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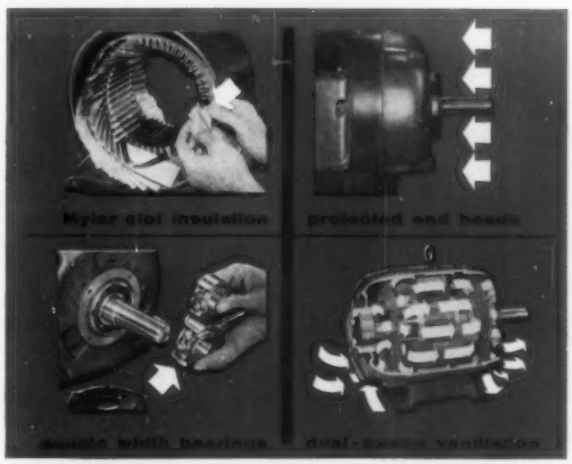

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New oxide ready for evaluation

Sporting a brand-new 50%-lower price tag (but still one of the most expensive materials in the engineer's kit), scandium oxide is on the hunt for new jobs, and may be well worth checking. Not much is known about it; but if, like scandium metal, it follows the pattern of the rare earths it may turn out to have useful electrical, electronic, and ceramic properties. Vitro Chemical Co. is now ready to supply it in gram and pound quantities.

The price: $2850—down from last month's $5500/lb. That's just for 99.9% material, though. You can get it 99.0% pure for $2750.

Cerium makes brass "super-plastic"

Carefully controlled additions of cerium can produce brass alloys that show an elongation as much as 150% greater than the unalloyed metal at the temperature of maximum plasticity (1350 F), Soviet Academicians Y. M. Savitskiy and U. K. Duysemaliyev report (*Doklady Akademii*, Vol. 131, #4).

To obtain the effect, the alloy must be held at 1325 to 1350 F long enough for full annealing. Pure cerium need not be used, though. The element can be added in the form of misch metal, the inexpensive rare-earth mixture (*PE*—Apr 25, p 39).

More refractory coatings by electrophoresis

Heat-resistant coatings of oxides and unusual ceramic-metal compositions, now being produced by electrophoretic methods, are described in several reports prepared for this week's Electrochemical Society meetings in Houston. These are coatings produced by deposition of particles dispersed in an aqueous or solvent carrier, rather than by conventional electroplating techniques.

For instance, electrophoretic deposition of aluminum in flake form is under study at Frankford Arsenal, where good results are being reported with several new solvent compositions. And diffusion of such electrophoretically deposited coatings on steel is being investigated.

Vitro Corp, continuing its work on electrophoretic coatings for molybdenum (*PE*—July 28 '58, p 5) now reports a molydisilicide–nickel composition that resists oxidation in air (under static conditions) to 2600 F. Specimens failed under thermal cycling at 1800 F, however, indicating that ductility needs improvement. Also under study by Vitro: electrophoretic deposition of solid-film lubricants on stainless steel.

Cermets deposited by a combination technique, using a suspension of ceramic particles in a conventional electroplating bath, are described by AMF researchers. Satisfactory coatings combining alumina, zirconia and molybdenum disilicide with such metals as chromium, cobalt, nickel, platinum, and tungsten have already been produced.

Fused salts as heat-transfer media

The technology of fused chloride salts has reached the point where equipment can be designed and operated at temperatures to 900° F "with a high degree of confidence," Brookhaven National Laboratory reports. Tests, covering periods of hundreds and even thousands of hours, were made in forced-circulation and thermal-convection loops.

Plenty of problems were found. The fused salt eutectics used (a mixture of lithium chloride and potassium chloride that melts at 660 F, and a ternary sodium chloride—potassium chloride–magnesium chloride composition melting at about 740 F) are subject to rapid reaction with atmospheric moisture, and all equipment must be thoroughly clean and leaktight. However, type 347 stainless steel proved satisfactory as a containment material and ring-type flanged connections were serviceable.

As to components, bellows-sealed and Y-pattern globe valves gave good service. Commercial needle valves did not. Likewise, sump-type canned pumps, with certain modifications, performed fairly well; while some other types did not.

A report on the work just completed, is being released by Brookhaven.

(Note: For more on high-temperature fluids, watch for PRODUCT ENGINEERING's special report on high-temperature fluids—coming soon). —ARG

WHAT'S HAPPENING IN RESEARCH . . .

Organic batteries being developed

Organic compounds that might serve as cathodes in magnesium cells and as anodes in other types of batteries are under test at RCA's Semiconductor & Materials Div.

In a series of reports prepared for delivery at this week's Electrochemical Society Meeting, engineers at RCA's Semiconductor and Materials Div describe several promising types.

Magnesium cells in which m-dinitrobenzene cathodes replace the usual manganese dioxide operate efficiently and at a practical discharge potential, and promise to provide high capacities on a weight basis. In these cells, the organic element is coupled to a standard magnesium anode; and placed in a magnesium bromide or magnesium perchlorate electrolyte. Theoretical capacity of an A-size battery is about 220 ampere-minutes for a magnesium efficiency of 65% and impedance is similar to that for the magnesium-manganese dioxide cells.

Several other reactive compounds are under test; among them, organic positive iodine compounds, and aliphatic azo compounds. In magnesium and aluminum primary cells, R. Glicksman and C. Morehouse say, these compounds give comparable capacities to mangnesium-zinc-manganese dioxide cells on heavy drain tests. Shelf-life studies indicate, though, that these might be more suitable for reserve cells than for dry cells.

More progress with plastic semiconductors

A report on one phase of the US Air Force's research program, and information on new metal-polymer types from the USSR, highlight the organic semiconductor field.

The US report, just released through the Dept of Commerce, details work done at Armour Research Foundation (*PE—July 4, p 9*).

Among the compounds under study are polytributyl tin methacrylate, ferrocene, and titanium-treated polyethylene. One important finding: Exposure to iodine vapor markedly increases the conductivity of many of these compounds, promises a significant improvement in some cases. The Armour report, PB161459, 35 pages (double-spaced), priced at $1.25, is available from OTS.

The Soviet report, from the Institution of Electrochemistry in Moscow, tells of semiconductors made by incorporating fine metal powders in plastic and rubber binders. Both n-type and p-type materials are being produced; the latter by mixing fine iron powder with polyisoprene or polystyrene and pressing to shape.

The n-type materials are made by vibrational grinding of the reduced iron with the resin monomers. This, the Soviets say, strips the oxide film from the metal and produces active centers for catalysis of the resin.

The Soviet report, by S. D. Levina and several co-workers, appeared in *Akademiya nauk SSSR*, Doklady, v.132, #5, 1960. A brief abstract is available in English, but no complete translation.

Supercooled titanium shows superstrength

Iodide titanium, cooled from room temperature to —452 F, increases 210% in tensile strength, says T. S. DeSisto and F. L. Carr of Watertown Arsenal.

Using the new tensile-test cryostat they described at the Cryogenic Engineering Conference (*PE—Sep 5, p 16*), they find titanium's tensile strength increases continuously—from 46,000 psi to 143,000 psi—as the temperature goes down. Elongation, on the other hand, first increases and then decreases. It goes from 60% at room temperature to 72% at —319 F, then drops to 59% at —452 F.

briefs . . .

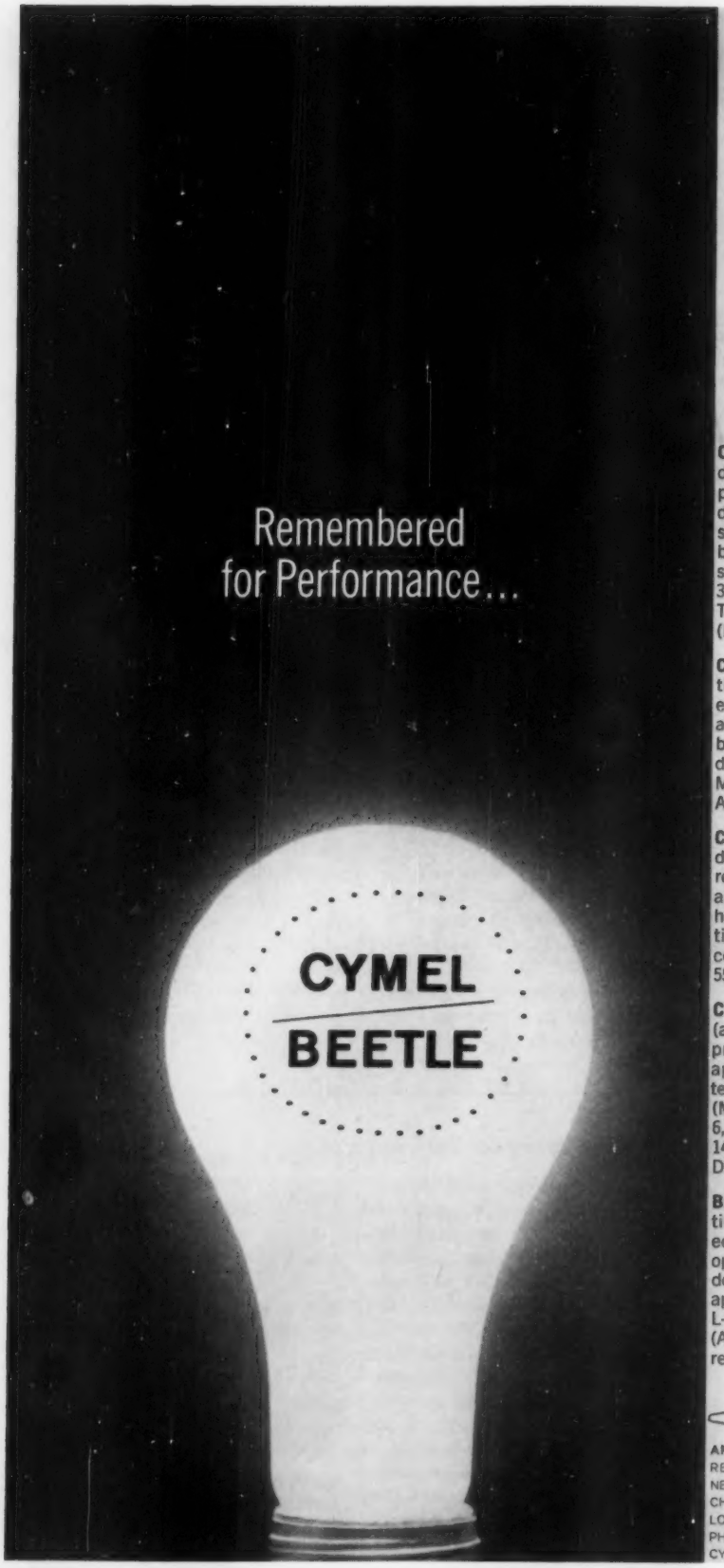
For plasma arc spraying at temperatures in the 15,000 F range, Norton Co is now offering a series of borides, oxides, carbides and nitrides. They can be obtained in several particle sizes, many in substantial quantities; others, like dichromium boride, molybdenum diboride, vanadium boride, and high-purity zirconium boride, in experimental quantities.

660 F is the top temperature for presently available elastomers, says Carl S. Marvel of the Univ of Illinois, and there's not much hope of any immediate breakthrough to truly high-temperature rubbers. However, he notes in an excellent review prepared for the American Chemical Society, both silicone and fluorocarbon materials are giving good service below this point, and much has been done recently to improve their thermal stability. Among the promising compounds for future development: polyesters, fluorine copolymers, metalloorganics. —ARG

British offer servo set for research

A build-it-yourself servo kit that can be assembled without special tools or precision fitting is being offered by Feedback Ltd, Crowborough, Sussex, England: the servo control unit—dc power supply, motor armature supply, servo amplifier, potentiometer supply, and mixing circuit—carries an export price tag of about $880 (shipping weight is 77 kg). A kit for a servo assembly like the one pictured is about $475 (shipping weight: 60 kg). A variety of mechanical components gears, cams, dial assemblies, and the like, is available individually at prices from about $1.50 to $9.

SERVO ASSEMBLY, supplied in kit form, includes servomotor tachometer, gear train, input and output potentiometers, plus mounting base.



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CYMEL 3135–3136 (glass-filled) Additional distinctive properties: outstanding electrical properties; high impact resistance; extraordinary flame resistance; good dimensional stability. Typical applications: circuit breaker boxes; terminal strips; connectors; coil forms; stand-off insulators. Specifications: Cymel 3135 (MMI-30, MIL-M-14E, Federal L-M-181 Type 8; ASTM D704-55T Type 8); Cymel 3136 (MIL-M-19061, MMI-5).

CYMEL 592 (asbestos-filled) Additional distinctive properties: resistance to atmospheric extremes; high dielectric strength. Typical applications: connector plugs; terminal blocks; a/c, automotive and heavy duty industrial ignition parts. Specifications: MIL-M-14E MME; Federal L-M-181 Type 2; ASTM D704-55T Type 2, SP1 SPEC NO. 27025.

CYMEL 1077 (alpha cellulose-filled) Additional distinctive properties: Surface hardness, heat resistance, unlimited color range. Typical applications: appliance housings, shaver housings, business machine keys. Specifications: MIL-M-14E – Type CMG (in approved colors); Federal L-M-181 Type 1; ASTM D704-55T Type 1, SP1 SPEC NO. 30026.

CYMEL 1500 (wood flour-filled)–CYMEL 1502 (alpha cellulose-filled) Additional distinctive properties: Good insert retention. Typical applications: meter blocks, ignition parts, terminal strips. Specifications: Cymel 1500 (MIL-M-14E Type CMG, Federal L-M-181 Type 6, ASTM D704-55T Type 6); Cymel 1502 (MIL-M-14E Type CMG, Federal L-M-181 Type 7; ASTM D704-55T Type 7.

BEETLE® UREA (alpha-filled) Additional distinctive properties: Economy of fabrication, economy of material, myriad translucent and opaque colors. Typical applications: wiring devices, home circuit breakers, tube bases, appliance housings. Specifications: Federal L-P-406A, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM), SP1 SPEC NO. 27026.

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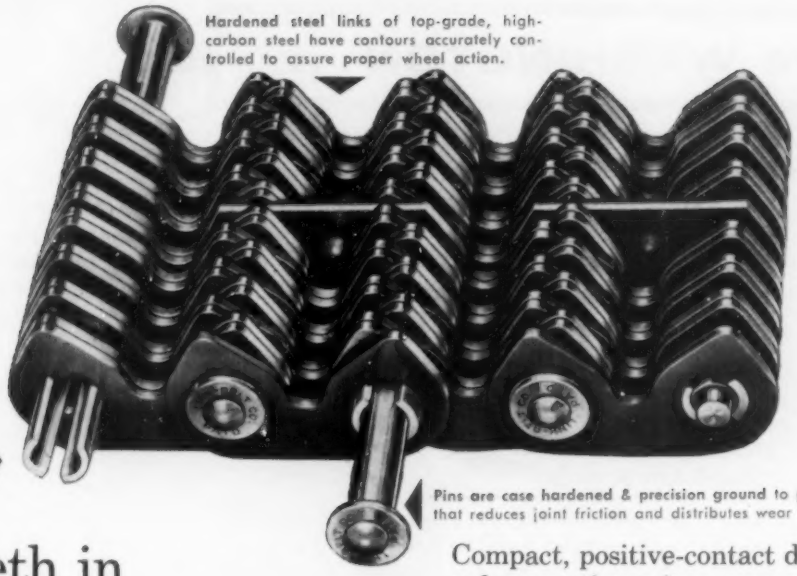
Hardened steel links of top-grade, high-carbon steel have contours accurately controlled to assure proper wheel action.
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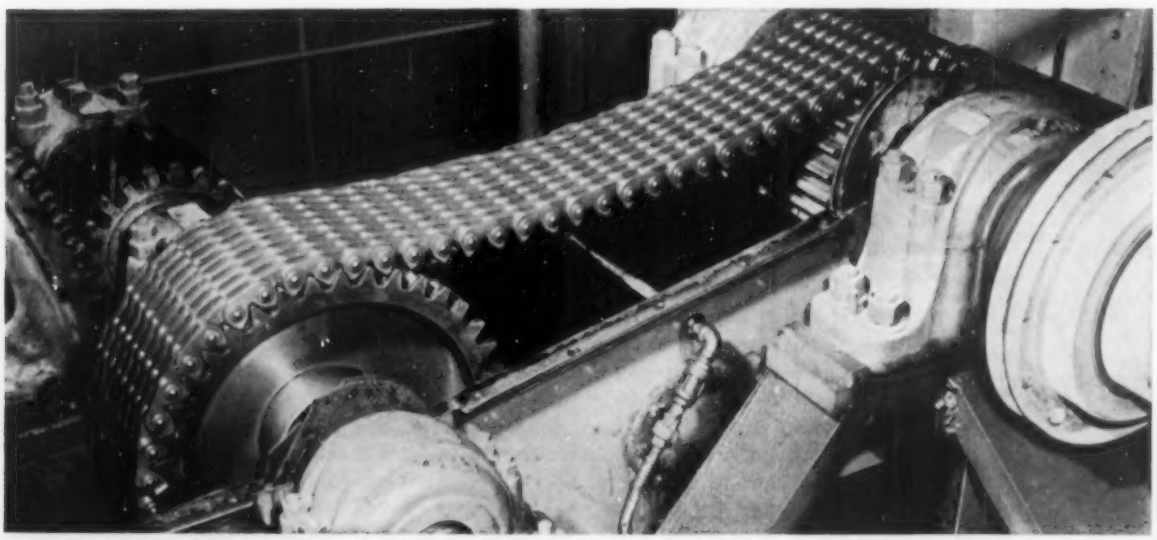

FROM WASHINGTON . . .

USSR to defrost arctic for northern sea route

Soviet scientists reportedly have a plan to thaw the frozen north by creating a space belt to capture more solar heat. **They believe that a belt of potassium particles placed in space between 70 and 90° north latitude would trap sufficient additional energy from the sun to warm up the northern hemisphere.** One big advantage would be to keep Russia's North Sea shipping routes and northern rivers ice-free for year-round navigation.

Such a plan would not affect the lower latitudes, the Russian scientists say. What they would do is put some 1.7 million tons of the particles in space 600 to 700 miles above the earth. The reflecting belt would then cause more solar heat to be reflected back to earth.

Right now, the scientists say, only about one 2-billionths of the sun's energy is reflected to the earth. Rockets would carry the particles into space where they would be dispersed by a special centrifugal apparatus.

NASA to coordinate materials R & D

A new division, for handling materials-research programs, has been set up by the National Aeronautics and Space Administration. **The office will coordinate NASA materials-research efforts with other government agencies and start new programs in areas where materials research is lagging.** Currently, NASA is spending some $7 million to $8 million a year on such research; it plans to step up activity in this area in the coming years.

Defense contracts include "VE" cost-cutting incentives

The Pentagon is turning to "value engineering" to cut costs in defense contracts. Also known as "value analysis" or "value improvement," the plan offers dollar incentives—half of the savings—to companies that come up with cost reductions on military specifications without impairing functional capabilities of new weapons or components.

The plan has been used by some of the services for some time. Now, however, "VE" clauses are being widely written into contracts. For example, Navy—which has led in value-engineering incentives over the past years in shipbuilding, has begun inserting formal clauses in most of its procurement contracts for equipment, components, etc.

The Army Ordnance Corps awarded its first production contract with a formal "VE" clause recently. It was a $2-million contract to Temco Aircraft Corp for production of wings and elevons for the Hawk antiaircraft missile.

Air Force says it has been promoting the same type of cost reductions on an informal basis. With top level Pentagon recognition for "VE" however, AF contracts will likely carry formal clauses soon, too.

Navy estimates it has saved $2.5 million over the past few years with the "VE" incentives. And General Dynamic's Electric Boat Div earned over $294,000 extra in construction of four nuclear-powered submarines. It proposed some 225 changes in specifications, use of materials, or production methods—the Navy adopted 94 of them. A $71,000 award was made for substituting electric stud welding for adhesives in attaching damping materials to the inside of the submarine hull. A $16,000 earning came when Electric Boat simplified valves in a snorkel exhaust system.

CIRCLE 13 ON READER SERVICE CARD →

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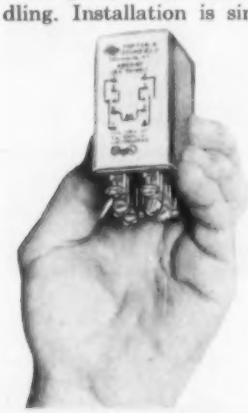
THIS P&B 10-AMP RELAY IS AS RELIABLE AS IT LOOKS

Our AB relay looks rugged . . . and it is. You can specify it for 10 amp switching and confidently expect 100,000 cycles. Yet it is compact, easily mounted, and does not require special handling. Installation is simple, using your preference of screw terminals (adapters), quick connects, or dip soldering.

Designers specify the AB for air conditioners and other products where dependable, continual service is paramount.

These standard AB and ABC relays are listed by Underwriters' Laboratories and Canadian Standards Association:



ABC Series—AB series can be supplied enclosed in sturdy metal dust cover, $1^{31}/_{64}$" x $2^{25}/_{32}$" x $2^{1}/_{32}$".

Type	Arrangements	Type	Arrangements
AB7AY	DPST-NO	ABC7AY	DPST-NO
AB8AY	DPST-NC	ABC8AY	DPST-NC
AB11AY	DPDT	ABC11AY	DPDT

Coil voltages: 6, 12, 24, 115 and 230 volts AC, 50/60 cycle.
Contact rating: 10 amps, 115 volts AC or 5 amps, 230 volts AC noninductive.

U/L File E-29244 CSA No. 15734

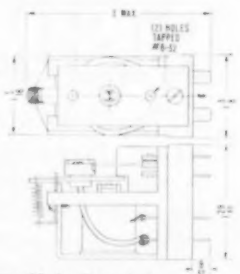
Write for complete data or contact your nearest P&B sales engineer.

AB AND ABC RELAYS ENGINEERING DATA

GENERAL:
Insulation Resistance: 100 megohms minimum.
Life: 3 million cycles (mechanical).
Breakdown Voltage: 1500 volts rms between all elements and ground.
Temperature Range: DC: −55 to +45°C.
AC: −55 to +45°C.
Weight: AB—5 ozs. ABC—7 ozs.
Terminals: Fit ¼" quick-connect terminals, or may be applied to printed circuits using dip soldering. Screw adapters furnished on request.
Enclosure: ABC: Heavy duty dust cover.
Dimensions: $1^{31}/_{64}$" x $2^{25}/_{32}$" x $2^{1}/_{32}$".

CONTACTS:
Arrangements: DPDT
Material: ¼" dia. silver. Other materials available.
Load: 5 amps at 230 volts AC or 10 amps at 115 volts AC noninductive.
10 amps at 28 volts DC.

COIL:
Voltage: DC: 6 to 110 volts.
AC: 6 to 230 volts.



Power: DC: 2 watts nominal.
AC: 6.4 volt-amps.
Resistance: 35,000 ohms max.
Duty: Continuous: DC coils will withstand 6 watts at +25°C.

MOUNTINGS:
AB: Two 8-32 tapped holes on 1¼" centers.
ABC: One 8-32 stud ⅜" long and locating tab.

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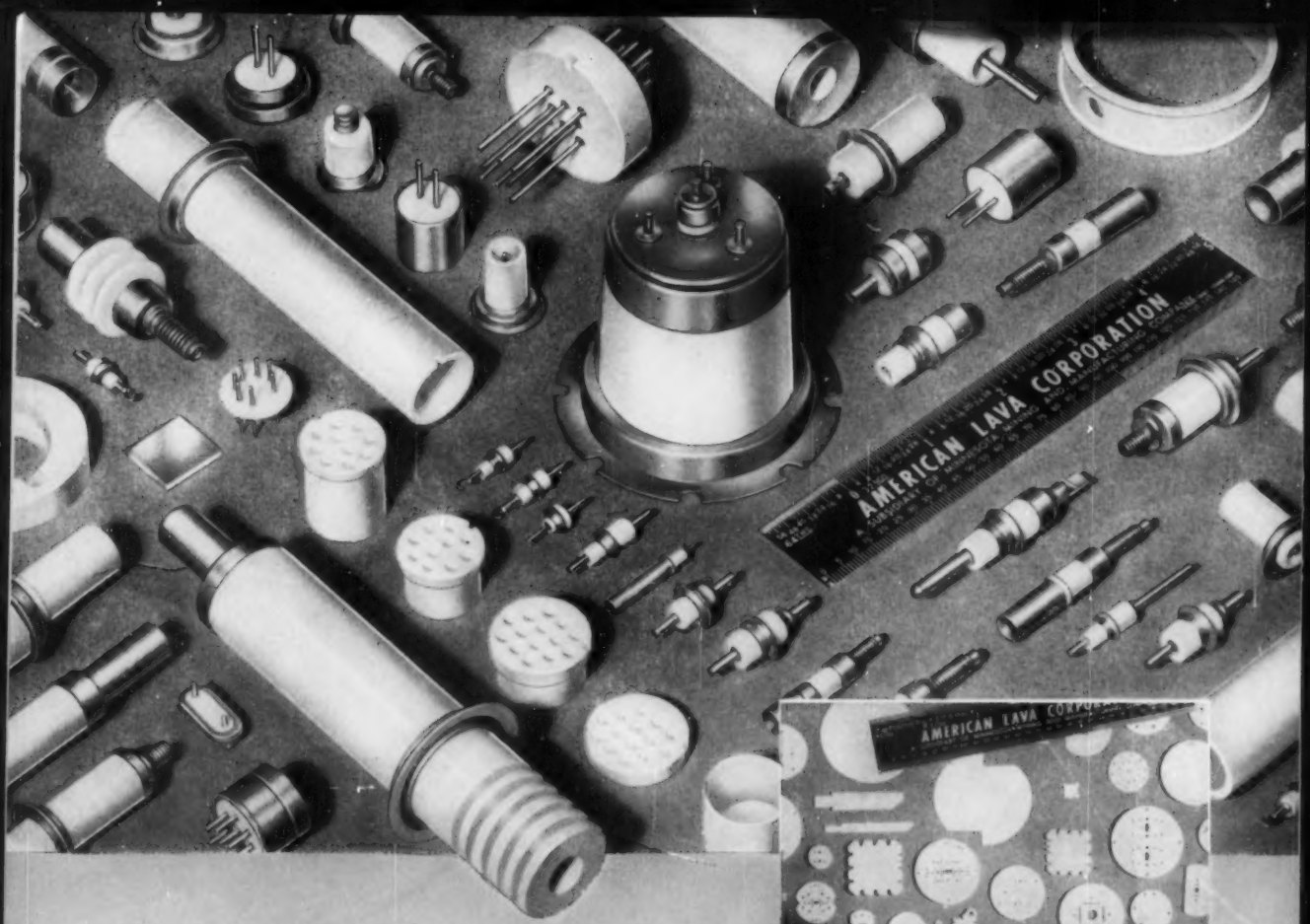

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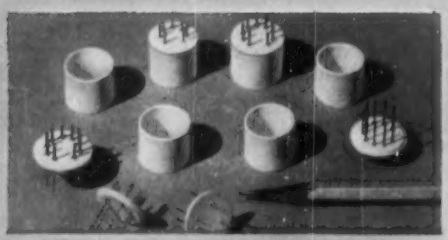
AlSiMag Ceramics offer exceptional resistance to heat and erosion. They have marked electrical and physical stability at elevated temperatures and in varying environments. Chemically inert. Good strength. Can be accurately fabricated in micro-miniatures.

AlSiMag Ceramics include many special purpose ceramics, some especially adapted to hermetic sealing. Widest choice of materials, more than half a century of specialized experience. Send blue print and operating conditions.

AlSiMag pioneered micro-miniature ceramics . . . some as thin as 0.005". Relatively high strength, superior performance at high temperatures, high frequencies. Excellent record for withstanding fatigue, heat, shock, vibration.



The AlSiMag Ceramics in these multiple pin headers may be safely used up to 2800°F. The metal components are the limiting factors.

These tantalum pins with nickel braze alloy operate around 1000° F. All materials are rugged. Strong hermetic seal. Low vapor pressure. High temperature bake-out is practical.

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THE ENGINEERING WEEK

Engineering Case History: Discoverer I to XV

Los Angeles — America's man-in-space program received a shot-in-the-arm with the successful mid-air catch of Discoverer XIV (*PE*—Sep 12, p 21), and, before that, the water recovery of VIII. Capsule XV was tracked to its drop point, though it was then lost before recovery. These, target triumphs, after several misses, have brought Project Mercury closer to fruition. But even the failures have added to America's over-all knowledge of what problems we face in space.

The Discoverer project involves 35 space shots and is being used to give reliable research information on the various phenomena of outer space. Each vehicle and capsule carries a different instrument package to test specific conditions met in orbital environment. Tests include: biological experiments leading to manned space flights; recovery techniques; military applications, and pure scientific research on the unknowns of space.

THE BOX SCORE

To date, 15 of the 35 Discoverer shots have been made. Discoverer XVI, planned for this month, will try a mid-air catch to bring back capsule containing live animals, probably monkeys. Here is the score to date:

DISCOVERER XII DIAGNOSTIC PACKAGE, used to obtain information about previous recovery failures in the program, monitored separation of capsule from Agena, retro-rocket firing, ejection of the rocket cone, parachute deployment, and other functions. Satellite and capsule had nearly four times the instrumentation carried on previous launches for capsule investigation.

• I—Feb 28 '59—After two cancellations caused by errors, the missile was fired. It failed to reach orbit; no attempt was made to eject and recover the capsule. Telemetry was unsuccessful and tracking sporadic.

• II—March 13 '59—Launch and orbit establishment successful. Tracking and telemetry followed the capsule and indicated a recovery parachute deployment over Spitzbergen. No air search or catch possible.

• III—June 3 '59—Capsule failed to achieve orbital velocity. Tracking and telemetry successful through launch and coast flight.

• IV—June 25 '59—Same as Discoverer III.

• V—Aug 13 '59—Launch and capsule separation successful after a stabilized orbit and attitude had been attained. Tracking and telemetry successful through separation. No recovery beacon signal received or visual sighting made, and the capsule was lost.

• VI—Aug 19 '59—Same as Discoverer V.

• VII—Nov 11 '59—An inverter failure prevented stabilization of the second-stage carrier—Agena—and subsequent capsule separation. Telemetry and tracking were successful throughout the flight.

• VIII—Nov 24 '59—Achieved a highly elliptical orbit with perigee at 120 miles and apogee stretched to 1000 miles. Orbit caused premature exhaustion of the vernier jets of the Agena, hence attitude correction at time of separation didn't occur. Telemetry indicated separation occurred but attitude probably caused reentry capsule to overshoot the recovery area by hundreds of miles.

• IX—Feb 4 '60—Discoverer failed to achieve orbital velocity. Tracking and telemetry are reported to have functioned satisfactorily through launch and coast.

• X—Feb 19 '60—An electronic failure 59 sec after lift-off necessitated missile destruction by range safety officer.

DISCOVERER XIV TAKES OFF—Agena stage and capsule being carried into orbit by a Thor IRBM. The reentry vehicle, carrying a heavily instrumented recovery capsule, successfully withstood the searing reentry heat, and ejected capsule was caught in mid-air by a US Air Force plane.

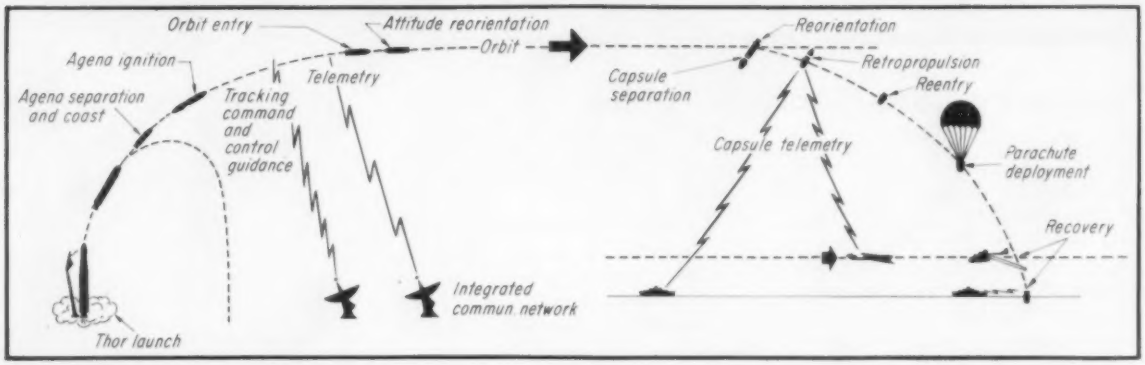
• XI—March 16 '60—Successful shot up to and including capsule separation. Immediately afterward some unknown action disturbed the capsule and it wasn't in the proper trajectory during retro-rocket firing. Capsule was lost.

• XII—June 29 '60—Orbital velocity not achieved due to defect in the attitude-control system.

• XIII—Aug 11 '60—Successful firing and reentry, with the first man-made object being recovered from space. Mid-air catch missed but the capsule was retrieved from the Pacific Ocean.

• XIV—Aug 18 '60—Successful

←CIRCLE 14 ON READER SERVICE CARD



LAUNCH-TO-RECOVERY SEQUENCE shows Agena capabilities of Agena vehicle. This carrier can orient itself in space, change attitude, and separate its capsule either by earth command or a self-contained program tape. Recovery is only of the capsule, the carrier either burning or falling into the ocean.

shot with a mid-air catch after Discoverer had completed 17 polar orbits.

• XV—Sep 13 '60—Vehicle orbited successfully and capsule ejected. Capsule landed outside of the catch area and was presumed lost until seen floating some 1000 miles outside the target area. Capsule, however, couldn't be found by search vessels and is again presumed lost.

And that's the score to date.

MORE TO COME

Discoverer is one part of a three-phase project using the Agena, a highly sophisticated final-stage orbiting vehicle, designed and manufactured by Lockheed Aircraft. In each phase, the Agena is slated to carry into orbit a different instrument package—Discoverer, Midas, and Samos. Discoverer is a series of research capsules; Midas, a missile-defense alarm system; Samos, a highly classified pictorial-surveillance vehicle.

Agena is carried into space by a Thor IRBM in the case of the Discoverer phase, by an Atlas ICBM for the other two. At separation, Agena propels itself into orbit and establishes a predetermined attitude depending on the job assigned to its capsule. It has the ability to sense deviations from its predetermined attitude and to make appropriate corrections. This is accomplished by vernier jets which are controlled by an inertial yaw and pitch control, and an infrared horizon scanner which detects the difference between sky and earth.

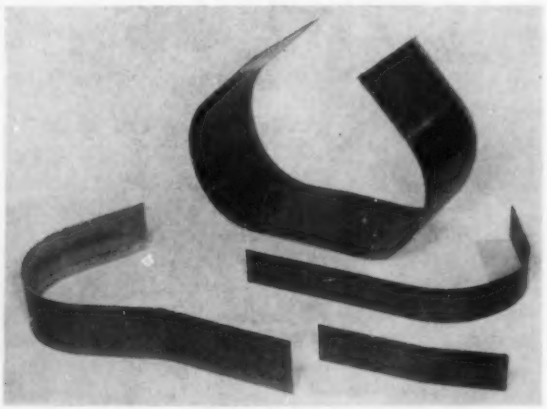
Attitude changes are also possible by command from earth or by a self-contained program tape. Agena has the potential to restart its rocket motors in space allowing for orbital changes and for placing the capsule into a reentry trajectory.

A Bell rocket motor powers the Agena. Thrust comes from the hypergolic reaction of inhibited red fuming nitric acid and unsymmetrical hyrdazine. How the reaction is initiated in the vacuum of space is still classified.

Newer models of the Agena will power Uncle Sam's moon probes and lunar-orbit vehicles.

—Bill Wallace, LA News Bureau

Plastic Sheet Forms Integral Shapes



Expensive molds and dies for instrument and machine housings, tanks, and containers may be replaced by a new process that forms intricately contoured parts of fiberglass-reinforced plastic sheet. Molded Fiber Glass Sheet Co, Ashtabula, Ohio, takes a strip of the material and shapes it to a pattern. A second strip is laminated to the first and the assembly is cured. By displacing the two strips by a a set amount, the parts of the assembly can be butt-jointed and bonded, or mechanically fastened to form an integral unit. Any wall thickness is possible and any curvature down to a radius of 3 in. Shown above are shapes made by the laminating process (left) and a completed tank with its shell formed this way. Die-molded heads are adhesive-bonded in place.

Who Threw the Fallout into Precious Metals?

WASHINGTON—The Atomic Energy Commission is probing a nuclear mystery which so far has shown several ingredients of an Erle Stanley Gardner "whodunnit."

Small amounts of a radioactive metal have turned up in the commercially distributed products of the precious-metals industry—but nobody knows how or why or when. It was after one precious-metals refinery discovered radioactive isotopes of ruthenium-106 in a mixture of ordinary ruthenium and rhodium (by-product of a platinum metals refining process) that AEC was called in.

But an entire division of atomic sleuths has been unable to find out exactly where the contaminating ruthenium comes from. It is a man-made product of atomic fission, and one guess blames radioactive fallout from atomic bomb explosions. Another suggested source is scrap fission products reprocessed after being taken from nuclear reactors. AEC inspectors are now checking US reactors on the last possibility and are also watching precious-metal inports which could have been contaminated by foreign reactors.

MORE THAN ONE REFINERY

After the first alarm, a check by the Commission Compliance Div, responsible for inspecting the AEC's 8000 reactors and isotope licensees, reveal that some half dozen other refineries were also distributing ruthenium that contained the "hot" Ru-106 isotope. Ruthenium's primary use is as a hardening and strengthening agent for platinum metals. It was determined by the AEC that none of the ruthenium leaving the refineries was alloyed with platinum in amounts greater than 4 to 5%. Commission investigators also found no use being made of the contaminated ruthenium other than in a dilute platinum alloy.

A further check by AEC indicated, fortunately, that as much as 80% of the alloyed ruthenium used after leaving refineries did not involve substantial human contact. For example, the platinum-ruthenium alloy in electrical wires and in certain electrical switch gear does not normally result in substantial radiation exposure.

The two cases involving greatest human exposure were instances where the radioactive alloys found their way into platinum used by jewelers for making rings, ring mountings and watches, and into the platinum base that dentists use for making individual false teeth. However, in each instance the AEC concluded that the contaminated ruthenium was in such dilute form that its radiation presented no health hazard. It was decided that no action would be taken to recover these products.

According to L. D. Low, head of AEC's Div of Compliance, the health hazard presented by the dilute ruthenium-106 alloys is, by comparison, not nearly so serious as that presented by strontium-90 bearing watches recovered by AEC and the American Rolex Watch Corp last December and January. At present, refineries and fabricators with stocks of Ru-106 are being required to dispose of it according to AEC instructions.

Meantime, Low has ordered eight Compliance Div field offices to continue the nationwide search to determine the course of the contamination and the extent of its distribution for commercial purposes. Names of individuals and companies involved in the radioactive metal distribution are being withheld by the commission pending final outcome of the hunt.

While the radioactive-ruthenium uses discovered up to now have all entailed dilute, low-level alloys, Low says that primary object of the continuing investigation is to ensure that none has been made or is likely to be made of unalloyed, 100% concentrates of ruthenium metal.

"If this happens, we'll have terrific problems," Low said.

—Richard Smith Washington Bureau

New French Machine Tools Stick to Plugboards and Copying Attachments

PARIS—Although Renault's prototype drill with numerical control rated as the individual standout, plugboard programers and copying attachments were most in evidence on automatic machines at the 1st French Machine Tool Show.

A tour around the display stands at the CNIT Centre National des Industries et des Techniques) Exposition Palace on the outskirts of Paris left visitors with the impression that French machine-tool builders and importers are cautious. These people feel there is at best only a limited market in France for machines with highly sophisticated numerical controls—and price tags reflecting that sophistication. French builders are moving more and more toward automatic operation, but they keep a sharp eye on cost when designing controls.

Representative of the French approach to automatic machining cycles was the automatic turret lathe displayed by SOMU. Here spindle speed, turret feed, cross-slide selection and the order of movements of turret and cross-slide in the cycle for each of the six turret positions are selected on a plugboard console separate from the machine. On the machine itself, dogs that actuate microswitches are set to get change-over from fast approach to cutting feed and, at the end of the cut, to fast return of the head.

SKIAKY ELECTRON BEAM WELDER welds zircalloy-steel nuclear reactor components in a vacuum. Workpiece, about 6.5 ft long, passes under electron gun control of welding cycle, varying longitudinal speed of workpiece between 4.5 in. and 85 in. per min., transverse speed from 0.2 in. to 40 in. per min. Column has 11.8-in. range of vertical movement.

Another variation turned up on the MAS lathe put on the floor by Strojexport, the Czechoslovakian export agency. On this machine a plugboard permits choosing 12 different feed-spindle speed combinations for each of two slides; copying attachments or cams control cross-feed. But instead of the usual arrangement of dogs and microswitches to change from fast approach to working feed, a drum mounted next to the plugboard is

continued on page 20

DOW

NEWS ABOUT PRODUCT DESIGN AND MATERIALS

Rare indeed is the design that cannot benefit from the application of today's plastics materials. From the ultra-high performance standards required by America's weapons program, to the equally high standards demanded by America's army of consumers, plastics are meeting the toughest tests head-on . . . and passing them with flying colors. For example . . .

HOW MODERN PLASTICS HELP MAKE MISSILES GO... BUSINESS FLOW

One of the most challenging problems today's design engineer has is the development of missile components that will stand up under severe firing conditions. In many cases, designers are meeting this challenge with the help of modern plastics materials. Here, for example, is how a Dow thermosetting resin helps keep the Minuteman Missile at readiness for instant firing.

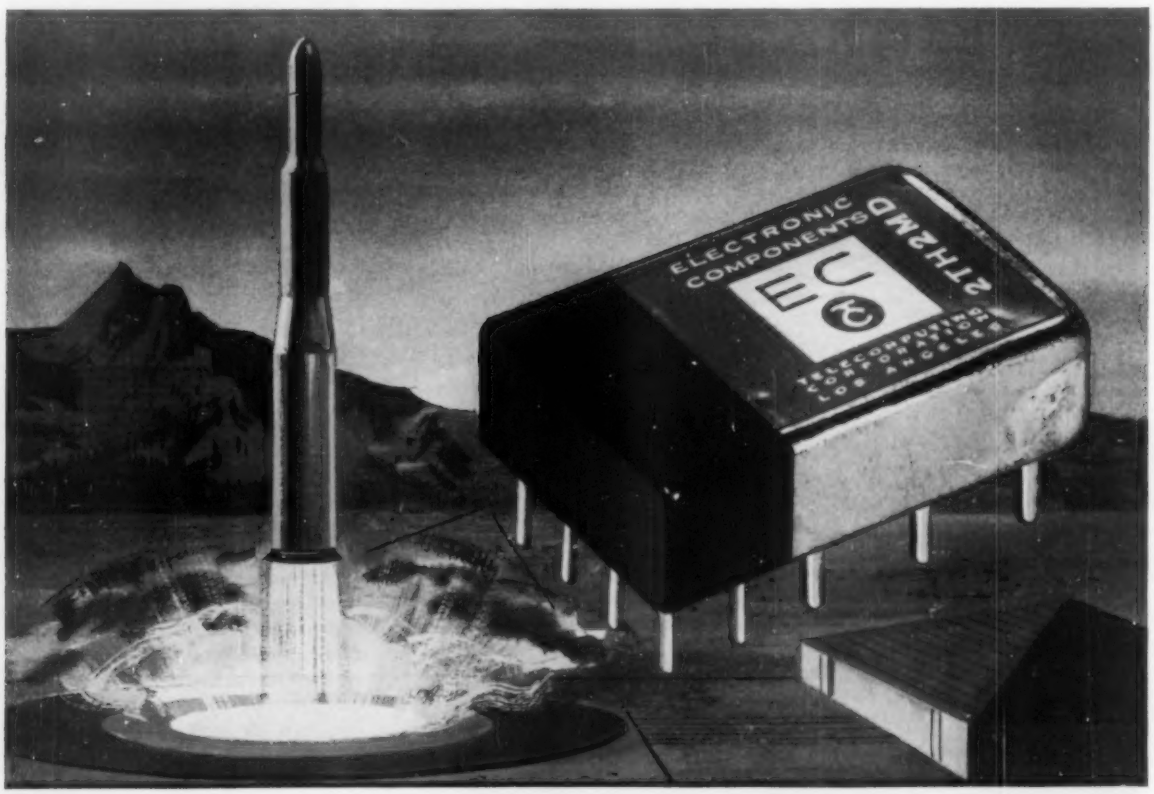
Producing relays for the ground checkout system of one of America's new missiles, a major electronic component manufacturer had to meet rigid design and performance requirements.

Their relay, a micro-miniature plug-in unit, was designed to be potted in an epoxy compound to give the connector mechanical stability and to assure electrical insulation.

In the process of selecting a potting compound, the designer made a series of heat and chemical torture tests. One test, to determine the effects of a prolonged, intense heat, was conducted with two potting formulations–one a high quality conventional epoxy resin, the other Dow Epoxy Novolac (D.E.N.* 438). The relays were placed in a 180°C. oven. After five hours, the conventional epoxy resin potting cracked. But after 100 hours of continuous 180°C. heat, the potted terminal made from Dow Epoxy Novolac was unharmed!

To compare the ability of each potting to withstand chemical action, they were soaked in a high-powered degreasing solvent. The ordinary epoxy resin formulation was completely dissolved after only 48 hours in the solvent. But the

*Trademark



potting made from D.E.N. 438 showed no significant change, even after two weeks' immersion in the same solvent!

Other applications, too. Whether it's for molding, encapsulating or laminating electronic components, or to give coatings and adhesives special qualities, designers are sure to benefit from the hardness, toughness, dimensional stability and chemical resistance of this new Dow polymer.

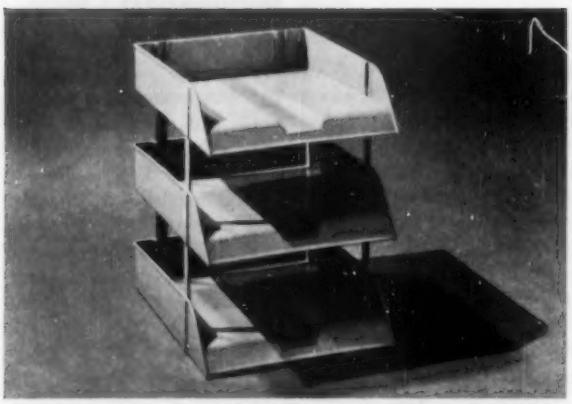
Other Dow plastics materials are performing equally important jobs helping to maintain the flow of modern business. Dow thermoplastics, for example, are contributing durability, attractive appearance, impact strength, moldability, chemical resistance, and other qualities to adding machines, mechanical pencils and pens, letter baskets, wastebaskets.

High impact resistance is one of the main qualifications for the cover and front panel of this adding machine. The designer chose a formulation of Dow polystyrene—Styron® 440—for its impact strength and low gloss. Furthermore, the parts made of Styron have built-in color, eliminating a four-step painting operation. The use of Styron 440 has provided a substantial savings in production costs, and combined with the designer's skill, has resulted in an attractive, compact, durable product.

The exceptional moldability of Tyril®, a Dow copolymer of styrene and acrylonitrile, not only gives these pen and pencil barrels an attractive, smooth, glossy appearance, but it enables the manufacturer to achieve a tight plastic-to-metal bond. Molded with finely detailed screw threads, the barrels hold the metal parts with exceptional strength, and can be screwed on and off, again and again without losing their firm grip on the metal.

Another formulation of Styron, Styron 475, gives an exceptionally high degree of impact resistance to a three-tier office letter basket. Styron 475 has three to five times greater impact strength and nine times greater elongation than general-purpose polystyrene formulations. Each tier is held up by thin posts of Styron 475 that fit into slots in the sides of the baskets. The high impact characteristics of this formulation prevent splitting or cracking at these points of stress, and combine this toughness with a pleasing, graceful appearance.

Molded in color, the flexible wastebasket of Dow polyethylene is a natural application of this versatile Dow plastic material. Inert polyethylene makes it sanitary and easy-to-clean, rustproof, noiseless. Available in a wide range of formulations for both molding and extruding, Dow polyethylene provides utility in a wide variety of applications.



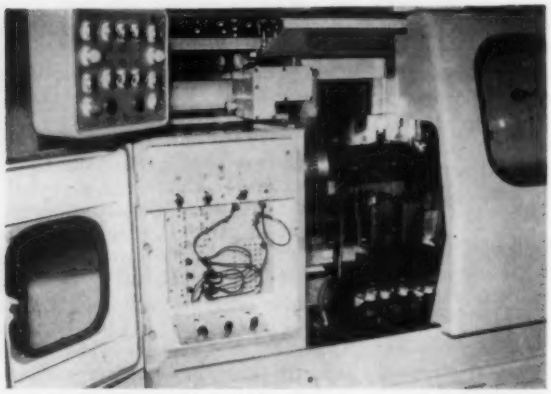
ARE YOU ON RECORD? Have you a design problem that might be solved by one of the versatile Dow thermoplastic or thermosetting materials? If so, drop us a line. We'll be glad to help you with specialized technical service—from choosing the best formulation to assisting in color styling. Write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Merchandising Dept. 1724DZ10-10.

See "The Dow Hour of Great Mysteries" on TV.

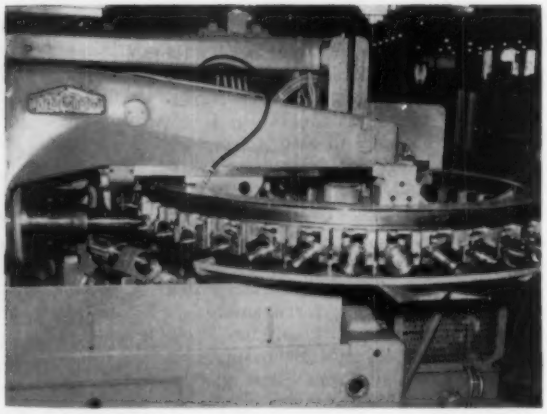
THE DOW CHEMICAL COMPANY

Midland, Michigan

DOW



AUTOMATIC MACHINING CYCLES on the Salome-Freres "Synchromat" lathe at French machine-tool show are set up on a plugboard located on the machine. Lathe has two parallel beds—with two longitudinal slides on lower bed, and a transverse slide with a hydraulic copying attachment on the upper bed. Special feature here gives constant linear feed along profile of workpiece. The copying attachment senses tool pressure and varies feed accordingly. When there is no copying attachment, two transverse slides can be used on upper-bed.



MERRY-GO-ROUND LOADER feeds gear blanks to La Precision Moderne hobber, then carries the finished pieces away. Blanks ride loosely in their carriers. Upon reaching work station they are cammed clear of the carriers by a ramp. After the machining operation, they drop back down into the carrier and continue on around; machine shuts off automatically when the merry-go-round has made the complete, 60-min. revolution. Merry-go-round is then unloaded and recharged with blanks.

continued from page 17

used. The Czechs also showed a drill with pushbutton selection of spindle speed and feed.

The tendency to keep automatic machines as adaptable as possible extends even to transfer machines. Polymechanique had on its stand a rotary transfer machine that turns out—at a rate of one every minute and a half—baseplates for hydraulic jack. The 14 heads on the machine perform 40-odd machining operations on each workpiece. In order to give the machine the flexibility to handle, in successive runs, a whole "family" of similar baseplates in different sizes, the heads are mounted on jacks. That way, they can be readily repositioned when the line is changed over to produce a different size; changeover takes about half a day.

Flexibility was also offered by the press manufacturer, Promecam. Its latest press, available in sizes from 16 to 250 metric tons, can be flipped over on its back to convert it from a vertical to a horizontal press.

The sole significant excursion into numerical control at the show was by Renault, which displayed a prototype drill operated from a punched paper tape. Coordinates of the holes (the reference point can be located either on the workpiece or outside it) plus instructions for the cycle are tapped out directly on the keyboard of the tape-punching machine. The machine converts the instructions into a binary decimal code. In the control console, the tape lies over a group of small pistons that actuate microswitches. Compressed air, fed to the tape-reading equipment, depresses pistons exposed by holes in the tape. That way, the preselected combination of instruction inputs is obtained for the transistorized control circuitry.

The control circuits develop the position signals for the X, Y and Z coordinates and compare them with the actual table and head positions, which are fed into the console from photoelectric cells that read a reflected code from disks on the machine. The resulting output signals actuate relays in the table and head drive-motor circuits. The control circuitry is arranged so that the final slow approach of the table to the preselected position is always in the same direction. Accuracy of the positioning is +0.1 mm (about 0.004 in.); repeat accuracy is 0.02 mm (about 0.0008 in.). The machine can also be controlled manually by dialing coordinate positions on the console.

In the prototype version, tool changes are not automatic. When the tape has a tool-change instruction punched on it, the machine stops and an indicator lights up on the console. The operator changes the tool manually and sets the spindle speed, by means of a dial on the console, to suit the tool. But the tape-punching equipment was designed with an unused line (there are 10 lines of information for each hole and only nine are used) that could be used for instructions to actuate a tool changer and set spindle speeds automatically.

—Art Erikson, Paris Bureau

New Measurement Center Aims to Close US Lag

WASHINGTON—The nation's first Institute of Measurement Science has been established here by George Washington University's School of Engineering. Formed with the support of the National Bureau of Standards and The Martin Co, the institute aims to train students in the field of metrology—the science of measurement. Classes start next Feb.

According to Dr A. G. McNish, chief of the metrology div, NBS, the lack of experienced people in this science is awesome.

"During the past year," he says, "requests by industry and government for calibration of gage blocks alone have increased from 300 to 1000 monthly. As a result, a priority system had to be established. Packing cases of important instruments of all kinds sent to NBS by industry for calibration are overflowing into the hallways of the bureau." ■

Fight Explosions With Explosions

NEW YORK—On May 27 an explosion was suppressed in an ore crusher at the Monsanto Chemical plant, Springfield, Mass. Outside evidence for this was hardly spectacular—the crusher merely shut down, automatically. But examination found charring in the intake chute of the machine . . . a blast had died at the moment of being born. This was in dramatic contrast to an unsuppressed explosion in the same piece of equipment on Nov 6, 1959. Then, the vessel walls were blown out and cinderblock room walls were damaged.

The difference was this: A Fenwal explosion-protection system had been added after the first explosion.

According to George Grabowski, manager of standard products for Fenwal Inc, Ashland, Mass, the protection system does two things: (1) detects explosion at inception; (2) suppresses the blast before it can become destructive. He explains that though a blast appears instantaneous to the naked eye, there is a finite lapse in time, measured in milliseconds, between ignition and buildup of destructive pressures. The guard system senses the initial pressure buildup or the first tiny flash of flame, then automatically reacts to snuff it out.

The blast is made harmless by a combination of actions, which may include:

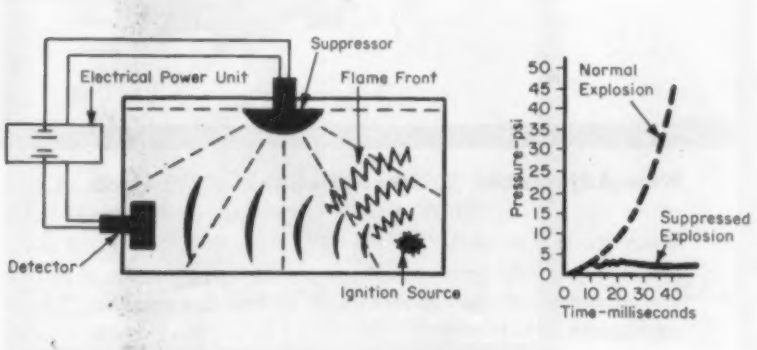
- Suppression—detonator kills the explosion with a fast blanket of liquid suppressant.
- Venting—opens a path to the atmosphere for controlled relief of pressure.
- Advance inerting—introduces a suppressant into areas remote from the source of the explosion to prevent secondary explosion of fire.
- Isolation—blocks the explosion from other areas.
- Automatic shutdown of plant or equipment.

The snuffed-out Monsanto explosion, caused by tramp metal dust collecting in the chute area, was stifled by suppressant—and automatic equipment shutdown followed. Here, metal dust was the cause; other explosions are caused by fuels, solvents, paints, varnishes, plastics, nonmetal dusts. Susceptible industries range from aircraft through chemical and petrochemical processing and refining, to metalworking and power generation. Case in point is the General Motors Livonia plant fire of several years ago which completely destroyed the Oldsmobile transmission-assembly line.

COMBINE STANDARD COMPONENTS

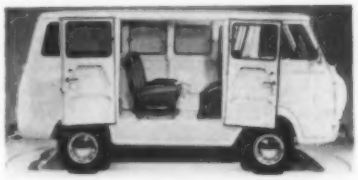
Although each protective installation is tailored to meet specific needs, a combination of standard components are used. Heart of the system is the explosion detector—either a pressure or radiation device—that senses the incipient explosion and, in conjunction with a power unit, generates an electrical signal. Pressure detectors are sensitive to either rate-of-pressure rise or to a specific static pressure, or both. Radiation detectors sense wavelengths of the spectrum in an explosive flame.

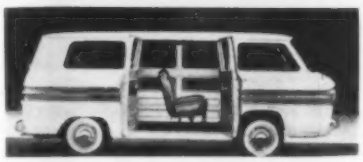
Protection devices may consist of suppressors, isolation valves or vents. All are operated by explosive detonators for rapid actuation. Suppressors may be easily ruptured hemispherical containers or high-rate discharge bottles. Both contain liquid suppressants. When activated, they dispense the liquid in fine particles moving at speeds up to 600 fps. The incipient explosion is cooled by heat of evaporation of the enveloping suppressant mist. The result is further inhibiting of combustion. ■



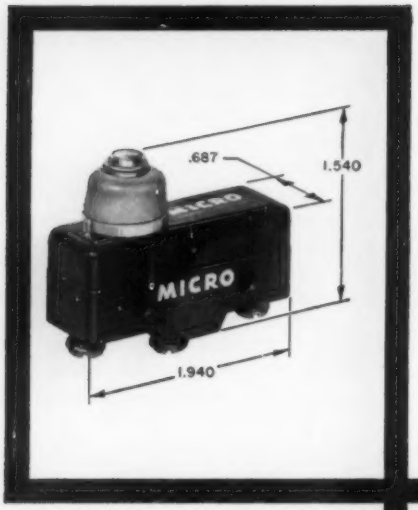
BASIC SUPPRESSION SYSTEM includes a detector to sense the incipient explosion and a suppressing agent that is dispersed explosively. The agent—water or bromochloromethane—extinguishes the explosion flame by chemical action and cooling, and also inerts the unburned explosive mixture. The graph shows the comparison between a normal explosion curve and a suppressed one.

Volkswagen Started a Trend





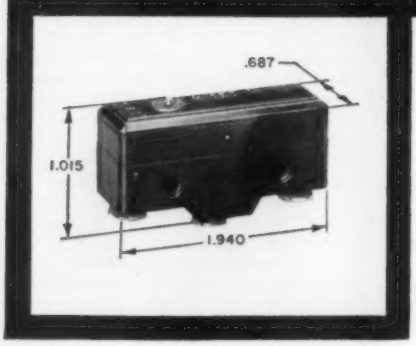
After following the lead of the foreign imports with compact cars, Detroit is now after the Volkswagen bus-type market. Sharp competition with Volkswagen is forecast by Ford (top) and Chevrolet (bottom) for their new short-wheelbase interchangeable vehicles—bus, van, pickup or station wagon. Ford's "Econoline" series is 168.4 in. long with a 90-in. wheelbase. It can carry 2 to 8 passengers. Rated payload is 929 lb with a road clearance of 7.0 in. Chevy's series has a 95-in. wheelbase and can carry 2 to 9 passengers depending on model—shown is a 6-passenger station wagon. Rated payload is 1600 lb. Forefather of both is the Volkswagen Microbus, which seats 3 to 9 passengers depending on arrangement. Overall length is 168.9 in., road clearance 9.4 in. Rated payload ranges to 1800 lb depending on model.



SWITCH NEWS FROM MICRO

Sealed Basic Switch. Type "Z" sealed switches have an elastomer boot around the plunger actuator and a cement seal around the cover, preventing moisture and foreign matter from entering the switching chamber. They are rated at 15 amperes, 125, 250, or 480 vac. Seven different actuator designs are available to accommodate various operating methods. Write for Catalog 62.

New 25-Ampere Switch. New "E" Series basic switches are UL listed for 25-ampere service at 125/250 vac. Ability to handle 75-ampere inrush currents makes them especially useful with solenoids, motors and heaters. Available in eight different actuator designs and four terminal types. Write for new Data Sheet 181.



New Adjustable "Differential Travel" Switch. A turn of the dial on this "10BS" Series switch varies its differential travel characteristic between 0.0025 and 0.007 inch. Designed for use as the precision switching element in sensitive control applications, it permits fine adjustment of the control's on-off cycling characteristics. Typical applications include pressure controls and blower fan controls. Contact arrangement is single-pole double-throw. Write for new Data Sheet 179.

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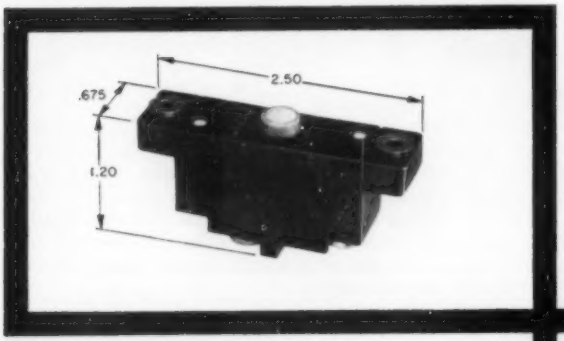
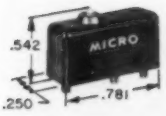
SWITCH

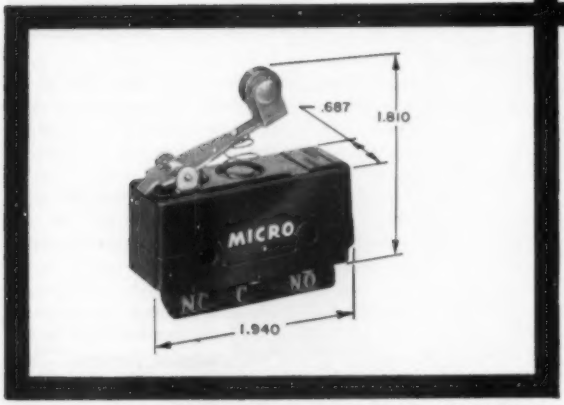
basic switch designs for precise, reliable control



Machine Tool Basic Switch. "3 MN" Series switches are designed for use with limit, sequence or control mechanisms on machine tools, presses and other industrial equipment. Single-pole two-circuit double-break contact arrangement permits a variety of wiring combinations. Its narrow width facilitates gang-mounting, while its unique terminal design eliminates the need for insulating barriers. Median mechanical life exceeds 10,000,000 operations at full overtravel. Write for Catalog 62.



New High Sensitivity Subminiature Switch. This "SM400" Series switch has a differential movement of only 0.001 inch max., without sacrifice of electrical rating or performance. An ideal switching element for pressure and temperature controls and other devices where ultimate control sensitivity or response is mandatory. It is also ideal where only a minute motion is available, or very low energy differential is a requirement. Rating is 5 amperes at 125/250 vac. Write for Data Sheet 180.



Double-Pole Double-Throw Switch. "DT" Series switches simultaneously make and break two independent circuits, providing a normally open and a normally closed contact with each pole for several different wiring combinations. Seven integral actuator versions are available. Write for Catalog 62.

Prompt engineering help on switch problems is readily available by simply calling the nearby MICRO SWITCH Branch Office listed in the Yellow Pages.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls, Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

POINTS OF VIEW

THE QUESTION:

Who Should Own the Rights to Commercial Products Developed at Government Expense?

"For our federal government to 'own' a manufacturing right . . .

would imply that it either intends to manufacture and vend the device or intends to confer this right to privileged groups for a fee. Pursuit of either alternative would clearly place the government in competition with business, and would strengthen its control of industry and commerce. Recently, a member of the Senate Select Committee on Small Business stated—'We think, or at least we hope, that all would agree the government is entitled to whatever it actually pays for and nothing more and nothing less.' We agree wholeheartedly, but what does our government actually want? To answer this we must know the objectives of government-sponsored work. In the defense field, the objective is to equip our nation's defense team with the most modern and effective equipment possible. This means we are seeking hardware that works.

"When the government pays for 'research' it seeks to understand something now unknown, to develop a weapon or a capability. If it pays for 'development' it seeks to refine or incorporate the known or existing 'state of the art' into a usable weapon. In each instance what is sought is hardware—an effective weapon, not an 'exclusive right to manufacture.' This latter is the traditional right of private enterprise.

"We must conclude that we cannot visualize how government 'ownership' of a patent would serve to promote our system of free enterprise. Indeed we must conclude it would accomplish just the reverse."

—ROBERT B LENT
Vice-president Riggs Nucleonics
Chairman: Gov't Relations Committee
Strategic Industries Assn

"It is in the interest of both . . .

the government and the public at large that the contractor own the rights to those products in his commercial field of interest. Today, and even more so in the future, our leadership as a nation is measured by our technical achievements. To maintain this leadership with the highest degree of certainty and at the lowest cost, our government must enlist the services of those companies having technical superiority in their fields of interest.

"Most of the industrial organizations doing research and development for the government have established their commercial position without substantial government support. They have attained a highly desired capability by organizing their facilities and employes in a manner to meet the ever-increasing needs of both the government and commercial interests. It follows that the products produced under a government development contract are normally the result of creative effort initiated by the contractor long before the contract was received. To ask the contractor to forego the ownership of developments using this background technology forces him to choose between his legitimate commercial interests and his obligations to meet the needs of his country.

"It would, of course, be wrong for the government to be without any rights of its own. This, however, is not the case. Under its standard procurement practice the government obtains at least a royalty-free license to all inventions made in the performance of the work under the contract. In addition, the contractor is required to furnish detailed technical reports during the course of the work. This is normally supplemented by data in the form of engineering and manufacturing drawings. With these rights and data, the government can seek alternative or additional sources of supply at its discretion."

—J W BIRKENSTOCK
Vice-president - Commercial Development
IBM

"During 1959, $8 billion of a total of $13 billion . . .

or 60%, of research and development performed by industry was financed by the federal government through research and development contracts. With the numerous advantages accruing to the recipient of a government research contract – cost-plus-fixed-fee contracts, assured markets, and considerable know-how, which is accumulated at government expense and gives the contractor tremendous advantage over potential competitors–it seems inconceivable that he is permitted, by most federal agencies, to retain the highly profitable commercial rights to inventions resulting from such contracts.

"This makes it possible for private concerns favored with government-financed contracts to prevent others from marketing the same goods and, of course, greatly increases the price of the products to the consumer. In addition, since most research and development contracts are given to a closed group of the country's largest companies, small-businessmen are excluded from entering many new fields opened through government-sponsored inventions and discoveries.

"Finally, the government-granted giveaway tends to slow down our economic and scientific growth, because it hampers the dissemination of new technical and scientific knowledge. Scientists and engineers working under a government contract for a private company, knowing that their end product will be patentable to their company's exclusive use, cannot share their accomplishments with scientists and engineers of another concern. Therefore, I have introduced a bill in the Senate to establish a uniform policy for all federal agencies which would require government retention of all commercial patent rights to products developed by private companies under government contracts."

—Hon RUSSELL B LONG
Select Committee on Small Business
US Senate

"There's only one way to look at it . . .

If a company develops a product for the military, even though it's funded by the government, the commercial applications should be proprietary and be made available for the benefit of all the people. It's good for business if a company such as Transval can qualify for a military contract and give the Department of Defense what it wants, then be able to make this product development available to all. Take the B-47 for example. When the military found that Boeing was able to meet its requirements for the aircraft, the company was allowed to produce a commercial adaptation, the 707, for use by domestic airlines. This was the forerunner of pure-jet travel for all Americans, and it has immeasureably speeded up our economy."

—BERJ HAGOPIAN
President
Transval Electronics Corp
El Segundo, Calif

"Our clients hire us . . .

to create new products or processes, and any resulting patents belong to them unless they wish it otherwise. So, too, when the government pays the cost of developing new products, title to the results resides with the organization that foots the bill. The government however, is acting in behalf of all the citizens in accordance with their desires and needs–not to carry out an arbitrarily established goal, or to make a profit. Thus the government might be interested in furthering a nationally determined objective like defense, the development of atomic energy potential, or the exploration of outer space. When byproducts of these major programs are suitable for profitable, commercial purposes, they should be made available to industrial use through liberal, non-exclusive licensing.

"Indeed, the national economy –and hence all of us–can be enriched by the exploitation of such new products through increased business. This not only helps meet the bills for the major programs, suited only to the federal capabilities, but has an added potential. Some of these products, modified for civilian use, can be adapted in turn for government needs. Thus the national agent has pursued its responsibility and incidentally made available to the greatest number all direct and indirect benefits."

—Lt Gen JAMES M GAVIN, USA (Ret)
President
Arthur D Little Inc

3M Makes Microfilm So Easy to Use

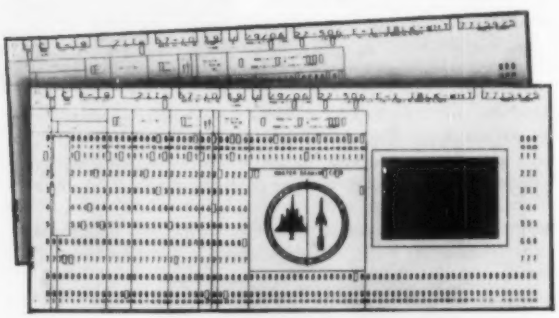
Industry-Proved 3M Microfilm Products Compatible with New Government Specifications, Speed Industrial Paperwork

In April, 1960, the trend to miniaturization and automation of engineering and related data leaped ahead with the release by the Department of Defense of the standards and specifications for its new Engineering Data Micro-Reproduction System.

Based upon, and compatible with, microfilm systems now being used by industry to speed industrial paperwork, the new requirements standardize the preparation and use of film, aperture cards, and eventually, equipment.

If you are now using microfilm for your engineering drawings and records, more than likely you will simply integrate the new requirements into your present system.

If you have held off instituting a microfilm program pending more information about the specifications, you will want your organization to familiarize itself with the new procedures right away. It's to your advantage because these new standards open broad avenues for control of industrial paperwork problems.



In any case, you can depend on 3M's industry-proved products to make microfilm so easy to use. Designed to meet military requirements, these 3M products raise marketing and production efficiency, and lower overhead.

FILMSORT Aperture Cards and "Duplicard" Copy Cards, long used by Government and industry, are designed to meet the specifications and standards for the Engineering Data Micro-Reproduction System. They standardize drawings and records. They consolidate pertinent data. They shrink file space. They speed retrieval of information. They simplify dispersal of needed facts. And now, to speed your use of FILMSORT Aperture Cards, 3M supplies both the printed card and the aperture. You save on shipping costs. You get your cards faster.

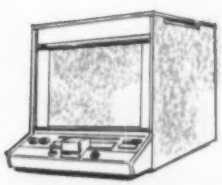
FILMSORT Microfilm Copiers, Mounters, and Readers are designed exclusively for FILMSORT Aperture Cards. They are engineered to make your micro-reproduction system practical.

THERMO-FAX "Filmac 200" Reader-

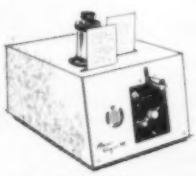
Printers combine the advantages of a reader and a printer in a single low cost unit. You can refer to the enlarged drawing on the huge viewing screen. When you want a print, just touch the button and in seconds you will have a clean, work-size copy—18 by 24 inches or 18 by 12 inches. With a THERMO-FAX "Filmac" Reader-Printer you can take more than a look—you can take a copy. Located at multiple points-of-use, the "Filmac 200" Reader-Printer will fit into your microfilm system perfectly. There's a new "Filmac 100" Reader-Printer, too, that delivers 8½ by 11 inch copies in seconds.

For complete information on how 3M makes microfilm so easy to use and details about the new Department of Defense microfilm standards and specifications, mail the coupon today.

Modern Microfilm Products from 3M . . .



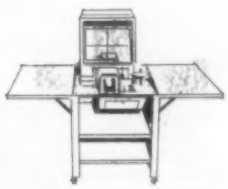
THERMO-FAX "Filmac 200" Reader-Printer



FILMSORT "Uniprinter" Copier

THERMO-FAX "Filmac 100" Reader-Printer

FILMSORT "Inspector 50" Reader



FILMSORT Semiautomatic Optical Mounter

3M COMPANY

MICROFILM PRODUCTS

THE TERMS "FILMSORT," "DUPLICARD," "THERMO-FAX," "INSPECTOR," AND "UNIPRINTER" ARE REGISTERED TRADEMARKS OF

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

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Dept. FBN-10100 St. Paul 6, Minnesota

Please rush me complete information about 3M Microfilm Products and details about the new Department of Defense specifications and standards.

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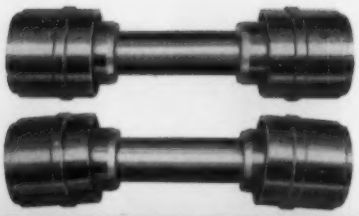
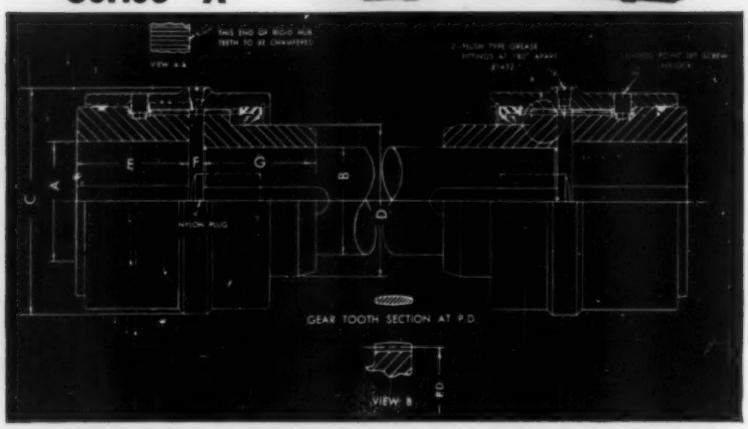
design facts....on

WALDRON High Misalignment Series "X"





COUPLING SIZE	H.P. PER 100 R.P.M.	MAX. BORE RIGID HUB A	MAX. BORE GEAR HUB B	C	D	E	F	G
1¼X	3½	1⅜	1¼	3¾	2	2⅛	¼	2
2X	12	2⅛	2	4 17/32	2⅞	2⅜	5/16	2¼
2½X	26	2¾	2½	5 9/16	3⅝	2¾	⅜	2¾
3X	50	3⅜	3	6 11/32	4¼	3¼	7/16	3¼
3½X	86	4	3½	7⅜	5	3¾	9/16	3¾
4X	130	4½	4	8 1/32	5¾	4¼	½	4¼
4½X	210	5¼	4½	9 1/16	6½	4¾	½	4¾

The Series X coupling is specifically designed for transmission of power in applications where shaft misalignment is too great to be handled by a standard gear coupling.

Each coupling assembly has two rigid hubs, mounted on drive shaft and driven shaft, each connected to a one piece sleeve by a spline used for driving purposes only. This spline extends only a portion of the hub length, and the remaining length of the hub is a turned surface which fits snugly into the counterbore in the sleeve to provide a suitable bearing surface. These two sleeves are connected by a floating shaft on both ends of which are mounted flexible hubs with gear teeth of unique design which permits misalignment up to 5°.

Series X couplings are easy to dismantle and reassemble. By backing off the set screws, the sleeves can be disengaged from the rigid and flexible hubs. Specially designed seals and steel protecting rings are held in place in the sleeves with Spirolox rings. End portions of the gear hubs are tapered for easy reentry of the seal in reassembly.

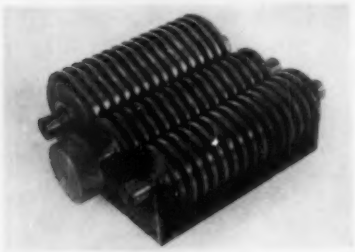
All load carrying parts are machined from high strength alloy steel. Floating shafts to customer specifications have nylon plugs inserted in each end to limit axial float and to prevent damage to the lathe centers of the roll shafts.

Write for Catalog

WALDRON Couplings

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
BOX 791, NEW BRUNSWICK, N. J.
SALES REPRESENTATIVES FROM COAST TO COAST

READER TO EDITOR



Early Twin-worm Gear

To the Editor:

Referring to your article about twin-worm gears published in your issue of Jan 18, p 39, we think it useful to call your attention to the following:

More than 10 years ago we used the same system for other purposes. Here is a photo of the first demonstration model of 1948. With this model, combined with the theory given by you, the new effects were shown.

—W G Bender
Grasso's Koninklijke Machinefabrieken N.V.
Hertogenborsch, Holland

Is "Winterization" Torturous?

To the Editor:

As one of the nation's leading designers and producers of military winterization, we certainly take offense at Alan Osbourne's reference to the word "winterization" as "outlandish". (July 25, p. 28). Winterization as a process enjoys eminent respectability in military and civilian circles, as the means for ensuring reliable operation of all types of machines in torturous arctic ambients down to —65 F. Winterization as a word has an equally high pedigree—using the suffix -ize (from the Greek "izein") meaning, among others, "to put into conformity with." A similar construction has given us atomize, palletize, satirize, and a host of other descriptive and concise terms.

We can be happy that the same inventiveness that gives us new machines to conquer new worlds also provides us with a living, growing language to describe our discoveries.

—Lloyd A Gerlach
Allen Industrial Products Inc
Menomonee Falls, Wis

Start Design Training Earlier

To the Editor:

I was pleasantly surprised to read your editorial in the June 27 issue, p 29, entitled "Too Many Tools." My observation is that some deans of engineering in science-minded institutions could profit by a weekly reading of this editorial for the next several years. It is nice to be on the frontiers of research—space, electronic or what have you—but the great bulk of industrial opportunities in engineering are in more prosaic assignments. I especially

like the idea expressed in your editorial of getting design problems down to the sophomore or even freshman years. The only other institution that I know of that is doing work along this line is Case Institute of Technology in Cleveland, where Dean Karl McEachron, formerly of General Electric Co. Education Department, has told me that Case expects to experiment with a design course at the freshman level.

When the so-called Grinter report was presented to the ASEE about five years ago, fear was expressed that there would be a split between those schools emphasizing engineering science and those retaining most of the elements of the traditional courses in the established professional engineerng groupings. Although there is some evidence in Purdue that there has been some reaction to the extremists in engineering science, the design courses in many institutions certainly have taken an awful beating in recent years. More editorials of the type just referred to will keep the practicing engineers better informed of these trends.

—Glenn R Fryling
Editor
Combustion Engneering

COMING EVENTS

OCTOBER

10-14 . . . Society of Automotive Engineers, National Aeronautic Meeting, Ambassador Hotel, Los Angeles

10-15 . . . Institute of Radio Engineers jointly with ASQC, Reliability training Conf, Texoma Lodge, Kingston, Okla

13-14 . . . Institute of Radio Engineers Symposium on Engineering Writing and Speech, Bismark Hotel, Chicago

16-21 . . . Society of Motion Picture and Television Engineers, International Congress on High-speed Photography, Sheraton-Park Hotel, Washington

17-19 . . . American Society of Lubrication Engineers jointly with ASME, 7th Annual Lubrication Conf, Statler-Hilton Hotel, Boston

17-21 . . . American Society for Metals, National Metal Exposition & Congress, Trade & Convention Center, Philadelphia

19-21 . . . . Society for Experimental Stress Analysis, Mechanisms in the Nuclear Age, Univ of Calif, Berkeley

20-21 . . . . Armour Research Foundation, National Conf on Industrial Hydraulics, Hotel Sherman, Chicago

23-26 . . . . American Gear Manufacturers Assn, Annual Meeting, Edgewater Beach Hotel, Chicago

27-28 . . . . American Society of Industrial Designers, Annual Conference, Edgewater Beach Hotel, Chicago

from MIDGET CARS . . .

to MIGHTY CRAWLERS

Both are driven by Rockford Spring-Loaded Clutches. These versatile power-links drive many vehicles of all types and sizes. Torque loads range from 50 to 2,530 ft. lbs.! Sizes vary from the compact 6″ clutch to the powerful 16″ double plate unit. Positive, full-motion driving power with smooth starts and controllability is yours with Rockford Clutches. Write today for illustrated brochure.

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CIRCLE 29 ON READER SERVICE CARD

CIRCLE 30 ON READER SERVICE CARD →

"Not one failure in 10 years with USS American springs"

Mr. Lee Dunn, Sales Manager of Walter Balfour & Co., Inc., tells why American Steel & Wire Springs are used in Balfour Doc-Port Rolling Steel Pier doors.

"The springs in our doors have to be exceptionally tough and dependable," says Mr. Dunn. "The performance of the doors is dependent upon the quality of the springs. The springs must act uniformly over their entire length because the doors must be perfectly counter-balanced at every point of travel. Springs of the same wire diameter and coil diameter *must* have identical characteristics. In the ten years we've been using American Steel & Wire springs, we've never experienced a failure.

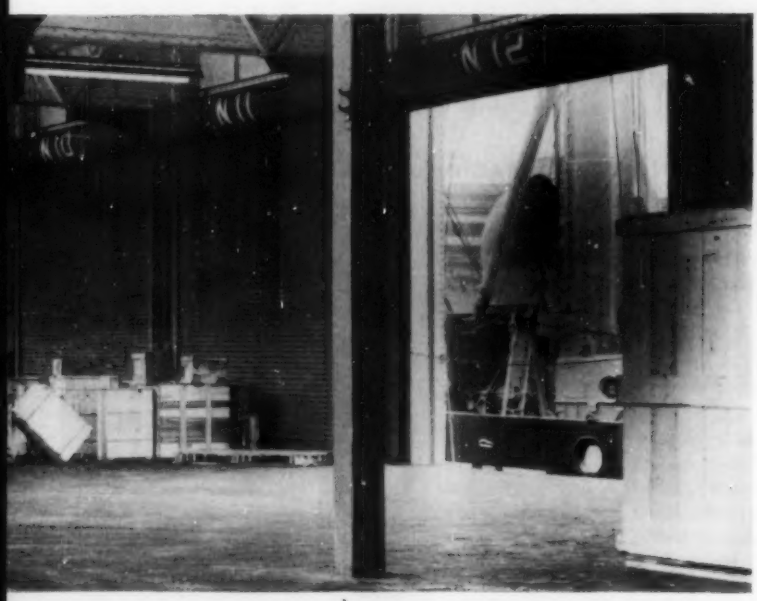
"Most of the USS American springs used by the Balfour Company are made from 7/16" cold wound wire. In the larger steel pier doors there are actually multiples of our helical torsion spring sizes . . . 5/8", 9/16", 1/2", and 13/32". Springs are nested one within another, each spring mounted on shaped cast anchors which are fixed to a single torsion rod, so that the springs are equally and simultaneously loaded."

When springs are your special problem, come to American Steel & Wire. Our Spring Engineering Service has a solid reputation for coming up with the right answer at the right time. They'll be glad to pitch in on your problem. Give us a call today, or write American Steel & Wire, Dept. 0403, 614 Superior Avenue, N.W., Cleveland 13, Ohio.

USS and American are registered trademarks

Cold wound springs in Balfour doors are placed inside steel cylinders and fixed on each end to anchors that prevent internal collapsing of the springs at contact points.

Balfour doors are exposed to heavy wind loads and salt water spray, but they can take it—and so can the USS American springs.

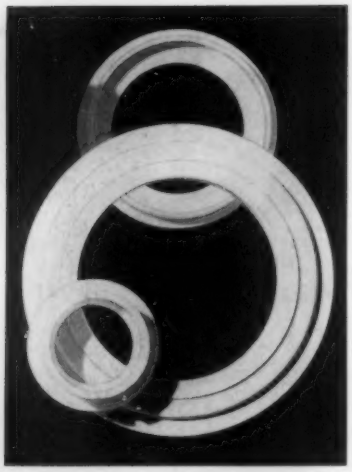


3000 lbs. ride on each USS American spring assembly every time these big 18′ x 24′ Balfour Pier doors open and close. It takes rugged, long-lasting springs to stand up under this kind of punishment.

USS **American Steel & Wire Division of United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Alabama, Southern Distributors
United States Steel Export Company, Distributors Abroad

Steel This mark tells you a product is made of modern, dependable Steel.



Corrosion and Abrasion Resistant Coors Ceramics Provide Long, Maintenance-Free Service Life

Mechanical shaft seal rings of Coors Alumina Ceramics give extended service life under severe operating conditions.

The extreme hardness and toughness of Coors Alumina Ceramics provide maximum resistance to abrasion.

In corrosive applications, seal faces will not pit or corrode, because Coors Alumina Ceramics are inert to almost all fluids.

Mechanical shaft seal units with Coors Alumina Ceramic parts are available only through seal manufacturers. For materials application, we stand ready to work with you in utilizing the unique properties of Coors Alumina Ceramics — prototype or production runs.

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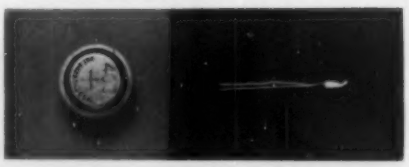
Midwest.....John E. Marozeck
FR 2-7100–Chicago, Ill.
Central.....Donald Dobbins
GL 4-9638–Canton, Ohio
East Coast.....John J. McManus
MA 7-3996–Manhasset, N. Y.
New England.....Warren G. McDonald
FR 4-0663–Schenectady, N. Y.
Southwest.....Kenneth R. Lundy
DA 7-5716–Dallas, Texas
Oil Field Industry.....William H. Ramsey
UN 4-6369–Houston, Texas

Coors
Alumina Ceramics
COORS PORCELAIN COMPANY
600 NINTH ST., GOLDEN, COLORADO

FOR YOUR INFORMATION (personal)

Then her wrist lights up



The manufacturer dangles these products with a proud claim: "the world's first and only electronic jewelry." They're charms, by Marchal, for a wrist bracelet. Though different in appearance, each pendant boasts two unique components: the world's smallest commercial light bulb, the Sylvania Mite-T-Lite (*PE*—*July* 18, *p* 57); and one of the world's smallest long-life batteries, the Mallory 400 (*PE*—*May* 12 '58, *p* 72). Besides the danglers pictured here, Marchal's initial line includes a globe and a Santa coming down the chimney. Also available: a gold key that carries its own light and battery. Prices range from $39 to $90. The key is $48 (solid gold, of course).

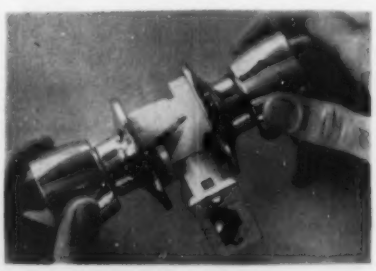
Workshop tips from the Navy

To help its own personnel, Navy's Bureau of Ships has long been collecting and publishing, in its own *Journal*, helpful hints for machine shop and maintenance work. The "tips" include procedures for reconditioning engine parts, and new splicing and fastening systems. The *Journal* itself is available from the Government Printing Office (20¢ a copy; $1.75 a year); but each issue, of course, contains only a few such tips. Now they're being gathered into a series of booklets, to appear semi-annually. The first, a 24-page publication (PB 161715) is now available from OTS, Washington 25, DC (price 50¢).

Seeing stars in red, white, and blue

You could buy blue stars, man-made for jewelry, just as crystals for masers and other electronic devices are made. Red stars of 100 carats or more—huge 1½-in. ovals were also on the market. (*PE*—Dec 14 '59, *p* 54). But not white ones. Man-made white star sapphires just weren't available. They are now, though—pure milk-white stars that look like opals. Linde Co is making them as the latest addition to its star line. And, says Linde, "they match the trend to lighter decorations," and cost barely $\frac{1}{10}$ as much as natural stones.

Nylon hardware for noiseless entry



A lockset that should operate even better in the 21st century than it does in the 20th is being placed on the market by Lockwood Hardware Mfg Co. All major internal parts are of nylon, and DuPont, which supplies the material, says proudly: "Tests showed that after 1.2 million cycles—equivalent to at least 80 years of use—the unlubricated locksets operated even more smoothly than when new." The design features mating chassis sleeves to prevent misassembly (see photo) and a self-aligning latch case. Cam and bolt are also nylon; but knobs will be metal, with a variety of finishes. —ARG

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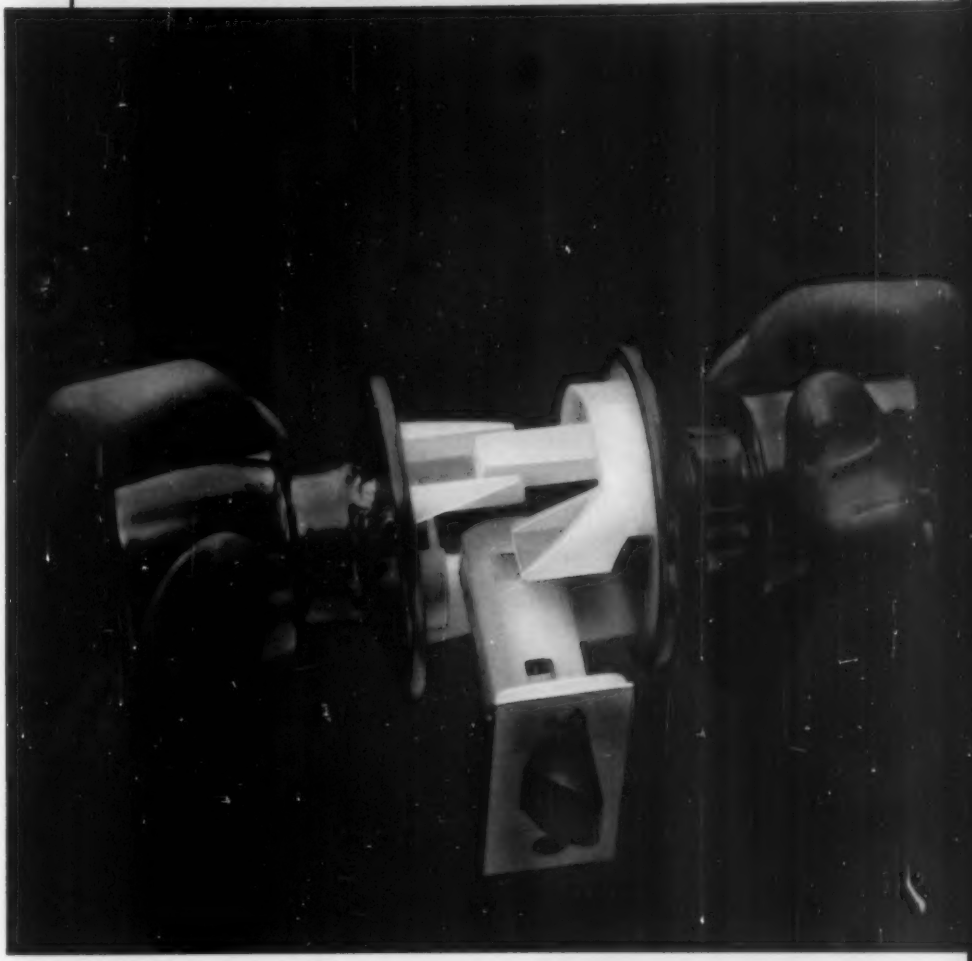
CIRCLE 33 ON READER SERVICE CARD→

work with

Du Pont Zytel®

one of Du Pont's versatile engineering materials



New lockset designed with ZYTEL® offers easy installation...lifetime service...economical production

This is the first plastic lockset ever commercially available—and it took a material with remarkable properties to make it: a material that is exceptionally tough and abrasion-resistant; a material with friction so low as to make lubrication unnecessary; a material that is rust- and corrosion-proof; a material that can be economically molded to close tolerances in large quantities, and one that requires little or no finishing.

In short, it took Du Pont ZYTEL nylon resin.

In this radical design innovation, almost all working parts except the knobs are molded of tough Du Pont ZYTEL. Installation of the lockset is made foolproof; round and square sleeves mate with round and square posts. The entire set is held by two lead-through bolts that drive directly into tap holes in the chassis sleeves. And a self-aligning latch case lets the installer swivel the latch to the right or left of the central lock assembly to compensate for bevel-edged doors or for improper boring. In action, the bolts of ZYTEL were tested up to 1,500,000 cycles—equivalent to more than 100 years of normal household use—before showing any perceptible wear. And the lockset functions smoothly and quietly without lubrication. The Lockwood Hardware Manufacturing Company of Fitchburg, Mass., reports that the parts of ZYTEL are economically mass-produced, need virtually no finishing operations.

On the following page, you will find further illustrations of the design improvements and cost reductions made possible by the complete line of ZYTEL nylon resins.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

working with

Du Pont Zytel®

one of Du Pont's versatile engineering materials

This "anti-gurgle" device is used by a major automobile manufacturer in cooling systems with hot-water heaters, to eliminate air bubbles and noisy heaters. Molded of a special ZYTEL nylon resin specifically designed for hot-water service, it costs only 25% of previously used copper part. (Molded by Kuhlman Plastics, Kansas City, Mo.)

Complex end-turn insulator molded of ZYTEL is used to simplify assembly and improve performance of fractional-horsepower motors. ZYTEL provides the necessary molding characteristics, good electrical properties, heat resistance and high strength in thin sections. (Molded by Carpart Plastics, Inc., for Redmond Co., Inc., both of Owosso, Mich.)

Feeding-finger pads for screw-machine stock are economically molded of tough, abrasion-resistant and resilient ZYTEL. According to the manufacturer, they are the best pads yet developed for feeding soft materials . . . and for centerless stock, where freedom from marking is important. (By T and M Engineering, Inc., of Valparaiso, Indiana, for Brown & Sharpe Mfg. Co. of Providence, R. I.)

Doing it better at lower cost: 3 more examples of ZYTEL® in action

The versatility of ZYTEL nylon resins stems directly from an unusual union of mechanical, chemical, electrical and processing properties. Some combination of these properties may well provide a solution to a design problem of yours. Find out more about the performance and cost advantages made possible by ZYTEL—simply fill out and mail the coupon below.

POLYCHEMICALS DEPARTMENT

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Room 2507Z, Nemours Building, Wilmington 98, Delaware
I am interested in evaluating ZYTEL for the following use:

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*Company*_____ *Position*_____

*Street*_____

*City*_____ *Zone*____ *State*_____

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

ZYTEL® *nylon resins*

one of Du Pont's versatile engineering materials

Alathon® · Delrin® · Lucite®

Henry Dreyfuss: man in a hurry

Dreyfuss talks design

If you could get Henry Dreyfuss to sit still long enough for a caricature, the drawing would inevitably show him with his coat half on and briefcase in hand. Most likely, he would be on his way to the airport. He's on the East Coast a third of his time, on the West Coast a third, and the other third in between.

Henry Dreyfuss has been busy ever since he gave up scenery design in the late Twenties and helped pioneer the business that is now called industrial design. In the early days, he gave a new look to everything from hinges to pianos, cigarette lighters to tractors. Today he can look back on a career of redesigning vacuum cleaners and gas stations, bowling alleys and ship interiors, typewriters and dental equipment, magazine formats and military strategy rooms, plumbing fixtures and the Nike missile launcher.

But Henry Dreyfuss is not one to look back. There are designs on his boards today that will influence our lives twenty years from now. "Time," he says, "is one of the designer's big problems. A design assignment is often three years in development. The item may not be on the market for another three to ten years. After it's introduced it will be in use for any number of years. In order to design that far ahead, our ideas have to be fresh, advanced and sprightly. It is a challenge to have to think as far ahead as we do."

One thing that goes a long way is the Henry Dreyfuss design credo, and it is all about people. "It says in effect," Dreyfuss states, "that the item is going to be ridden in, sat on, looked at, talked into, operated or in some way used by people. If the point of contact between the product and people causes friction, we have failed.

"On the other hand, if people are made safer, more comfortable, more eager to purchase, more efficient, or

just plain happier—we have succeeded." And succeed Dreyfuss does, by following this yardstick for effective industrial design: 1. Safety and convenience of use. 2. Ease of maintenance. 3. Cost, including tooling, production and distribution. 4. Sales appeal. 5. Appearance.

Selection of the right material for the job plays an important role in satisfying each of the five requirements. As a matter of ethics and sheer common sense, Henry Dreyfuss, like any member of the American Society of Industrial Designers, will not endorse any one material. "We have worked with all materials. What we want is the material that is right for the job. We look for the material that combines reasonable cost with the ability to be fabricated economically, and at the same time will give the product the built-in quality and durability it needs to sell well." With no-nonsense requirements like that, it is not surprising that a great many Dreyfuss-designed products use steel in one way or another.

Steel has strength, integrity and honesty. Steel is what the designer is apt to call a 'natural.' Dreyfuss feels that the public's image of steel depends largely on the product itself. A massive steel vault door conjures up an image of strength, imperviousness. Stainless Steel tableware suggests style and modernity. Steel curtain wall panels give buildings the look of tomorrow.

The moral is this: steel has been with us for ages, yet it is the modern metal, the metal of the future. Its enduring modernity will continue to be recognized, and used, by designers like Henry Dreyfuss.

(turn the page for a new look at steel)

USS TRADEMARK **United States Steel**

designing with USS High Strength Steels

Good design goes beyond material selection. Once the choice has been made, the designer's job is to take full advantage of the material's properties. Few materials offer designers as much opportunity as high strength steels.

COR-TEN Steel was developed by U.S. Steel and first used in 1933.

USS COR-TEN Steel is a name that has become a byword in design circles. It is a time-tested, high strength low-alloy steel. Structural designers welcomed COR-TEN Steel because it allowed them to pare dead weight and to lower maintenance costs. As structures, mobile equipment and machinery got bigger and bigger, dead weight became more of a problem. Even when weight could be shaved without stress problems, durability suffered. This high strength steel answered both problems.

Dead weight in stationary structures is costly; in mobile equipment dead weight requires more power to move.

USS High Strength Steels' yield points are all 50,000 psi min. compared to 33,000 psi for structural carbon steel.

Strength did it. COR-TEN brand and other USS High Strength Steels have a 50% higher yield point than structural carbon steel. They permit as much as 33% weight reduction. They have superior resistance to atmospheric corrosion and abrasion, so there is little reason to overdesign. Their fatigue and impact properties are excellent. Here is a quick look at three well-known USS High Strength Steels:

Send for the manual described at the right for a comprehensive guide on how to design with high strength steels.

USS COR-TEN Steel has a yield point 50% greater than structural carbon steel, has four to six times its resistance to atmospheric corrosion. It is used to do any one of these three things: 1) in slimmer sections to cut weight at no strength loss; 2) in equal sections to increase load-carrying capacity, cut maintenance and lengthen life; and 3) any number of combinations of 1 and 2. COR-TEN Steel also has greatly superior paint adherence and is used where a longer interval between repainting is wanted.

USS TRI-TEN Steel, with its 50% higher yield point than structural carbon steel, has superior notch toughness at low temperatures and keeps rugged equipment operating even in sub-zero weather. Its high endurance limit makes TRI-TEN Steel ideal for mobile equipment that must take repeated loading and reversals of stress. It is a natural for welded structures and bridges.

MAN-TEN Steel costs only about 20% more than structural carbon steel; TRI-TEN Steel about 36% more, and COR-TEN Steel 42% more.

USS MAN-TEN Steel also has a 50% higher yield point than structural carbon steel, and is the low-cost member of the family. Weight reduction as little as 17% with MAN-TEN Steel will save money on material cost alone. MAN-TEN Steel is a tough, durable steel and widely used in earthmoving equipment, truck frames, material handling apparatus and riveted bridges.

High strength steels represent but a few of the over 3000 grades of steel in existence today. United States Steel makes a complete line of high strength steels, as well as constructional alloy, stainless and carbon steels. Bring your design problems to us. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS, COR-TEN, MAN-TEN and TRI-TEN are registered trademarks.

USS United States Steel

Cranes have to operate in all-weather temperatures and are subject to stress and shock. That's why many of them are made of tough TRI-TEN Steel.

Light standards stay good looking for years because of COR-TEN Steel's outstanding atmospheric corrosion resistance. Paint life is extended. Slim design is made possible by COR-TEN Steel's strength.

TRI-TEN Steel has cut weight and cost of dozens of major bridges. In the bridge shown here, TRI-TEN Steel saved a quarter of a million dollars.

One of the first applications of COR-TEN Steel was in hopper cars for weight reduction and longer life. Today, use of COR-TEN Steel can save hundreds of dollars over the life of a car.

MAN-TEN Steel, used in truck frames and body members, reduces dead weight and increases payload.

The LPG cylinder business uses considerable amounts of MAN-TEN Steel because of its strength, cost and ease of fabrication to lighten the weight.

This mark tells you a product is made of modern, dependable Steel.

Here's a book that is in the hands of thousands of engineers and designers. It is your guide to the design of lighter, stronger equipment and structures.

design manual for high strength steels

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United States Steel
Room 6151
525 William Penn Place
Pittsburgh 30, Pa.

Please send me "Design Manual for High Strength Steels"

Name_____

Title_____

Company_____

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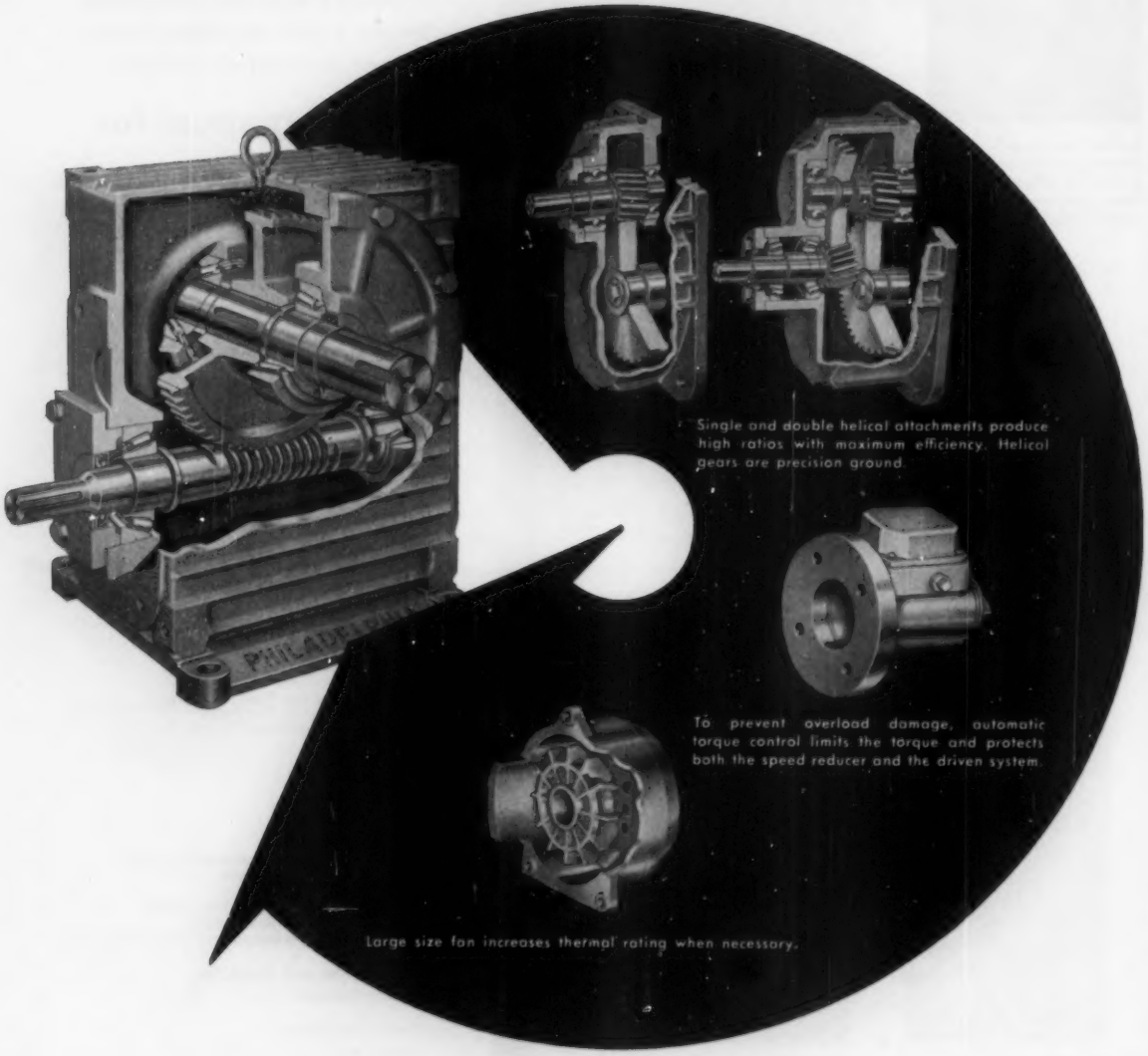
City_____ Zone____ State_____

Want higher worm gear efficiency?


Single and double helical attachments produce high ratios with maximum efficiency. Helical gears are precision ground.
To prevent overload damage, automatic torque control limits the torque and protects both the speed reducer and the driven system.
Large size fan increases thermal rating when necessary.

THEN HERE IT IS... FROM PHILADELPHIA

Here's new high efficiency in heavy duty worm gear drives that has never been available before. Helical attachments for double and triple reduction units combine the efficiency advantage of helical gearing with the high ratio advantage of worm gearing. You save on power... operating temperatures are lower... gearing lasts longer.

New high capacity, too. Improved tooth forms, precision ground alloy steel worms, special high strength bronze gears, heavy duty housings, precision ground helical gearing ... all add up to higher capacity in less space. In many instances you can save up to 50% in space, 40% in weight.

Delivery from stock of any drive arrangement and any mounting arrangement. Ratios from 5⅓:1 to 6150:1. Center distances: 3 in. to 21 in. Torque control attachments are also available from stock. For complete data, write for catalog WG-60.

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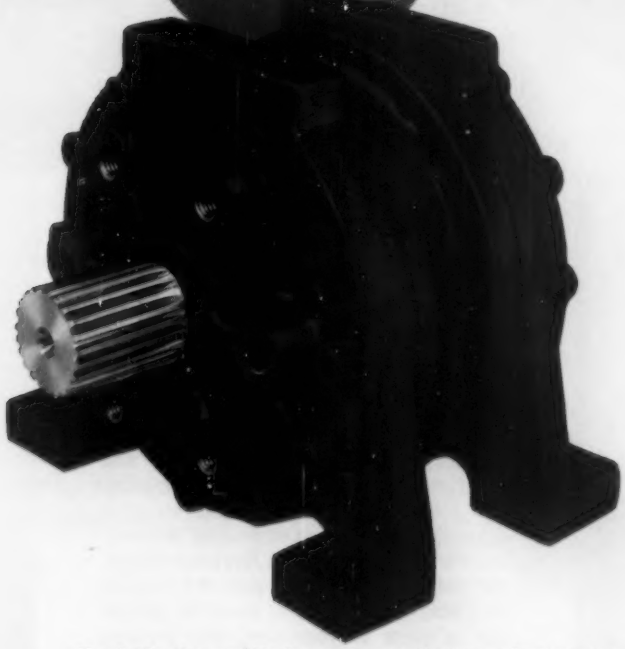
HYDROAC



Houdaille announces a new HYDRAULIC ROTARY ACTUATOR

for commercial applications

Houdaille, the world's foremost manufacturer of rotary type hydraulic equipment, now introduces a compact and powerful hydraulic rotary actuator for industrial use. Called HydRoAc, the Houdaille unit is designed to be used in a tremendous variety of applications ranging from turret lathes to farm machinery—from dump trucks to printing presses.

The superiority of Houdaille HydRoAc units is indicated by these specifications for standard units now available.

- Efficiency to 95% or over.
- Torque range from 1500 to 702,000 inch pounds @ 3000 p.s.i.
- Angular travel up to 280°.
- Operating pressure range from 250 to 3000 p.s.i.
- Low starting (friction) torque.
- Can be foot, end or flange mounted.
- Highly responsive for servo system use.
- Bearings, splines and other requirements to suit your needs.

Special units and other configurations available on custom orders.

Send in this coupon for more information on Houdaille's HydRoAc

Please check potential use...

Turning	Lifting
Locking	Tilting
Indexing	Driving
Steering	Counter balancing
Bending	Controlling
Clamping	Valve operation
Adjusting	Revolving
Lowering	Closing
Opening	Metering
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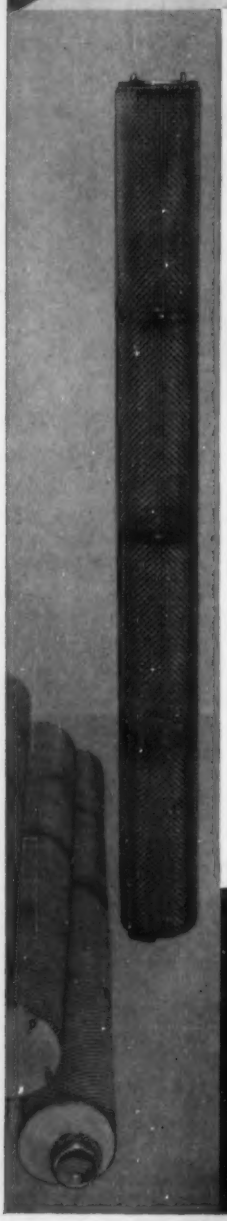
... Specialists in rotary type hydraulic equipment

Houdaille Industries, Inc.

Buffalo Hydraulics Division • Dept. C, 537 E. Delavan Ave., Buffalo 11, N. Y.



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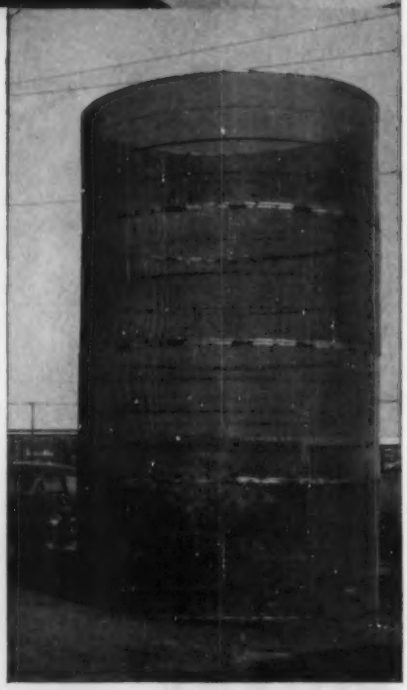

10 good reasons for choosing Dynamatic Eddy-Current Speed Control Equipment

1 Adjustable speed from AC power
2 Accurate speed control
3 Wide speed range
4 Rapid response
5 Low power loss
6 Simplified construction
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8 Quiet, efficient operation
9 Low maintenance cost
10 No commutators, rings, brushes, or rotating coils

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A wide range of standard and special control features may be obtained from electronic or transistorized magnetic amplifier control systems. The addition of an eddy-current brake to standard couplings or drives provides smooth, cushioned stops and controlled deceleration.

Dynamatic Eddy-Current Equipment is available in sizes from ¼ hp Ajusto-Spede Drives to heavy-duty Magnapower Couplings rated up to 20,000 hp—and larger.

Place your speed control problems in the hands of experts. Our representatives, located in all principal cities, are fully qualified to discuss your speed control problems and suggest Dynamatic Equipment that will do the best job for you. Call Dynamatic today—there is no obligation.

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CIRCLE 43 ON READER SERVICE CARD 43

Alcoa Alloy 6262-T9*—another Alcoa first—promises to become a standard in the screw machine products industry

*Patent applied for

a comparison of the characteristics of ALCOA SCREW MACHINE STOCK ALLOY 6262-T9 with other ALUMINUM SCREW MACHINE STOCK ALLOYS

	6061-T6	2017-T4 and 2024-T4	2011-T3
Strength	better	better(1)	better
Machinability	better	better(2)	not as good
Corrosion Resistance	same	better	better
Finishing Characteristics	same	better	better

(1) Based on Yield Strength
(2) Depends on Method of Machining

RELATIVE CHIP SIZE RATING
2011-T3: 1.0 6262-T9: 1.4 2017-T4 and 2024-T4: 2.0—3.0 6061-T6: 4.0

Visit the Alcoa exhibit, Booth 1410, National Metals Exposition, Philadelphia, Pa., October 17-21, 1960.

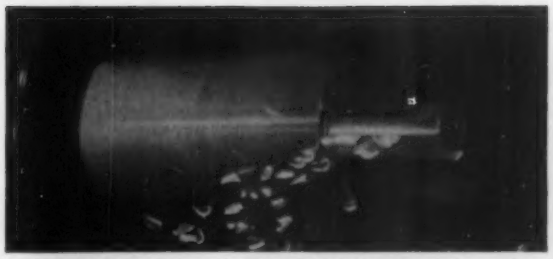
ALCOA'S NEW ALLOY 6262-T9 IS EXPECTED TO REPLACE ALLOY 6061 ENTIRELY AND 2017, 2024 IN MANY APPLICATIONS.

DESIGN ADVANTAGES—Higher typical properties (58,000 psi tensile strength, 55,000 psi yield strength, 10 per cent elongation) than 2011, 2017, 2024 and 6061—better corrosion resistance and finishing characteristics than 2011, 2017 and 2024—not subject to stress corrosion cracking.

ECONOMIC ADVANTAGES—Buyers can reduce inventories—stock one or two alloys instead of four—streamline purchasing—order in larger quantities.

PRODUCTION ADVANTAGES—Better machinability than 2017, 2024 and 6061.

For complete information, specifications, delivery of the newest aluminum screw machine stock alloy—Alcoa 6262-T9—call your nearest Alcoa sales office, or distributor, or write: Aluminum Company of America, 841-K Alcoa Building, Pittsburgh 19, Pa.



HIGHER STRENGTH—6262 offers higher strength than alloys 2011, 2017 and 2024.

BETTER CORROSION RESISTANCE—6262 offers better corrosion resistance and finishing characteristics than alloys 2011, 2017 and 2024.

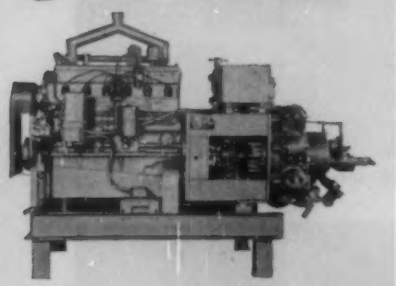
BETTER MACHINABILITY—6262 offers better machinability and higher strength than alloy 6061 . . . corrosion resistance and finishing characteristics comparable to 6061.

ALCOA ALUMINUM

SCREW MACHINE STOCK

AIR CONDITIONING POWER

"Proven reliability of International engines has led to the universal acceptance of Ready-Power air conditioning equipment." Report from Norb Hall, Manager, Air Conditioning, Ready-Power Co.

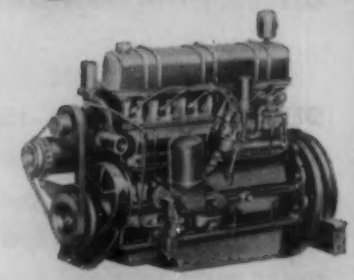


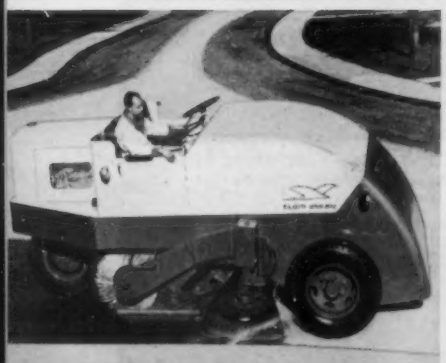
HANDLING POWER

"On-the-job reports prove that International power is an excellent choice." H. P. Lockhart, Ass't General Manager, Sales, Austin-Western Construction Equipment Div., Baldwin-Lima-Hamilton Corp.

MAINTENANCE POWER

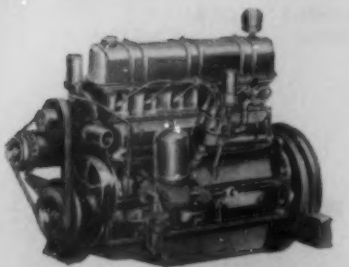
"We chose International power because of the wide speed range and favorable torque-speed curve." Report from J. Roberts, Chief Engineer, Galion Iron Works & Manufacturing Co.

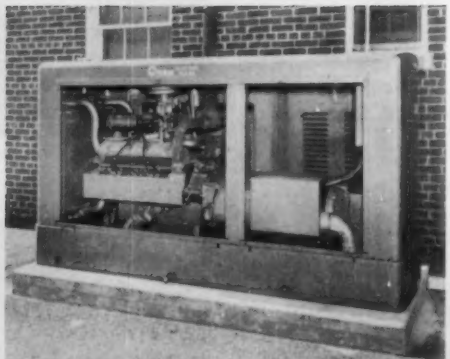




MUNICIPAL POWER

"We needed heavy-duty engines with superior sealing that would keep working under extremely dusty conditions." Report from R. Schmidt, Chief Engineer, Elgin Sweeper Co.





AUXILIARY POWER

"Onan equipment is built for 100 per cent dependability, so we chose International engines when specs called for water-cooled power." Report from J. C. Hoiby, Vice President, Engineering, D. W. Onan & Sons, Inc.

UTILITY POWER

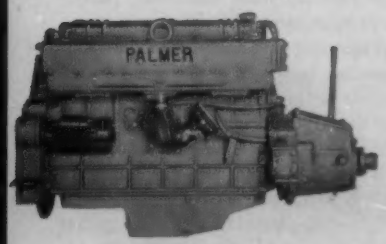
"International engines help give all four models of our earth augers fast digging action, high speeds coming out of the hole, and clean throw-off." Report from H. B. Williams, President, Hugh B. Williams Manufacturing Co.

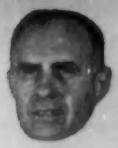
MARINE POWER

CONSTRUCTION POWER

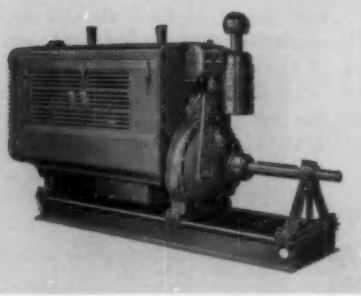
GROUND SUPPORT POWER

"Our sales have increased over 500% since we began using International engine assemblies five years ago." Report from R. C. Bolling, President, Palmer Engine Co.





"International diesel engines meet our standards for efficiency, dependability and parts and service coverage." Report from Guy Banister, Chief Technical Engineer, Barber-Greene Co.



"The wide range of power in the International line fits in with our plans to offer a wide selection of models." Report from Roger Frantz, Design Engineer, Hobart—Motor Generator Corp.

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Efficient and dependable power is assured for products of leading engineers, who specify IH engines for a wide variety of applications. Design engineers serve many different industries, but they all have one common problem: to find the most practical, economical and efficient power for their products. If you have the responsibility for selecting the power for your products it will pay you to check International engines because—

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CIRCLE 47 ON READER SERVICE CARD

Gasket engineering

GASKET GAUGE vs. TORQUE RETENTION

Gasket thickness is one of several factors affecting retention of initial torque loads. New study indicates significance of minor variations in gauge.

E. M. SMOLEY
Research Physicist
Armstrong Research and Development Center

Relatively small changes in thickness can produce significant variations in the torque retention characteristics of a gasket. This is one of the conclusions of a general study of the torque retention problem made at the Armstrong Research and Development Center.

Generally, this work confirmed the widely accepted idea that for maximum torque retention it is desirable to use the thinnest gasket possible. But the magnitude of variation produced by changes in gauge was greater than previously estimated.

One phase of the study is charted above. In this curve, torque is plotted along the vertical scale, and uncompressed gasket thickness is indicated along the horizontal scale. The initial bolt torque was 20 pound feet for each of the materials tested.

After 18 hours at 300° F., the thinnest gasket (1/64″) showed an exceptionally low torque loss of only ½ of 1%.

Increasing the thickness to 1/32″, the loss rose to 39%. The loss for 1/16″ material was 68.5% of the initial torque load.

It is estimated that bolts at least 5″ long would be required to wipe out most of the torque loss on the 1/10″ material. Actually, 1″ bolts were used in all these determinations.

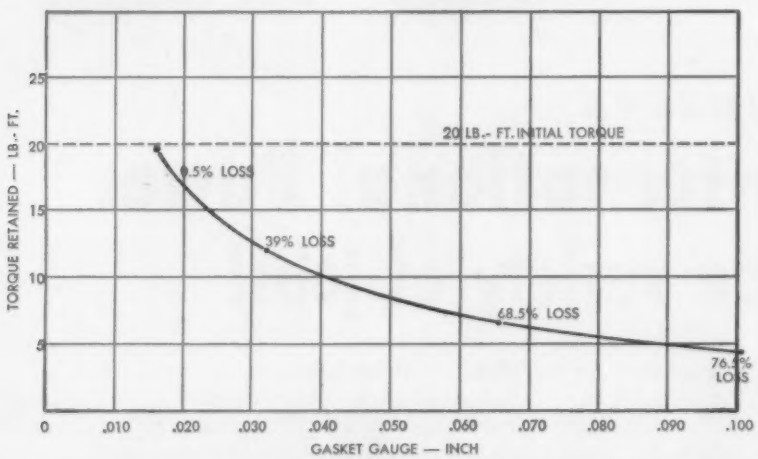
Aside from mechanical advantages, another reason for using thin gaskets is, of course, that they cost less. And they also minimize extrusion, particularly with straight rubber gaskets.

Armstrong engineers point out that there are factors that limit gauge reduction beyond a certain point. One is that to provide a seal, gaskets must be compressed more than the cumulative deviation from perfect parallelism of the two flange surfaces.

For example, take a 1/32″ gasket cut from a material normally capable of a 50% compression. If used where the cumulative inaccuracies of the flanges are more than 1/64″, leaks will result. The alternatives are to use a thicker gasket or a more compressible material.

Joint designs that permit bowing between flange bolts also work against the use of thin gauges. The same alternatives may provide a solution in such cases.

Gasket thickness is only one of many factors in gasket engineering that are under study continuously at the Armstrong Research and Development Center. Much detailed information on this work is contained in the Armstrong Gasket Design Manual. Write for your copy today. Address Armstrong Cork Company, Industrial Division, 7110 Irvin St., Lancaster, Pennsylvania.



In this test, four gauges of one beater-saturated asbestos fiber gasket material were put in steel flanges, with bolts torqued to 20 pound feet. The assemblies were heated at 300° F. for 18 hours; retained torque was measured while flanges were hot.

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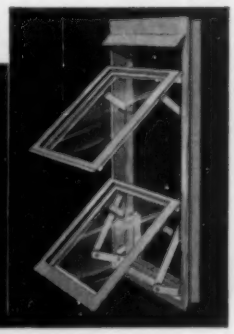

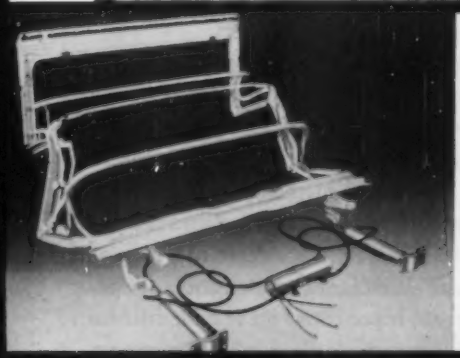

Dura Actuators raise and lower head and foot sections of Dura Select-A-Rest adjustable bed.

Dura Actuators raise and lower convertible tops, car windows, rear decks, etc.

Dura Actuators operate marine clutch and transmission mechanisms, power steering, and can tilt and lower large outboards.

Those "magic muscles" for opening, closing, lifting, lowering, pushing, pulling, turning, starting, stopping things—the team at Dura has more experience in them than any other team in the country, maybe in the world.

AND ideas. Experience begets ideas, good ideas, ones that work—and save your money.

For instance, millions of fingers press buttons in automobiles for things to happen and Dura Actuators MAKE them happen—windows go up or down, tail-gates or trunk lids move, seats move in any of half-a-dozen directions, convertible tops go up or down, lock and unlock, or ride levelers are adjusted. And, that's only the automobile business. Dura's "magic muscles" work in scores of applications, in fact, in ANY application where an electro-mechanical or electro-hydraulic actuator is the logical and thrifty answer.

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Consutrode alloys are made by vacuum remelting electrodes of a predetermined composition by an electric arc. The white heat of the arc—8000 F—breaks down many nonmetallics in the electrode. Considerable degasification, as well as substantial improvement in cleanliness, is achieved by the furnace vacuum which removes the oxides and nitrides released in melting of the electrode.

Controlled solidification of the molten metal in a water-cooled crucible is a principal advantage of the consumable electrode vacuum process. This gives an exceptionally sound and homogeneous ingot.

Other recently developed methods for improving steels and properties of the improved alloys are described in a new booklet, "Modern Melting at Allegheny Ludlum." It includes a description of Special Air Melted Steels, Invac alloys made by induction vacuum melting, Invacutrode alloys made by remelting Invac electrode stock by the consumable electrode vacuum process, and Consutrode alloys.

This new booklet is packed full of charts and graphs—a real help to anyone who must get the most out of metals. Ask your A-L representative for a copy or write: ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept. PE-10.***

ALLEGHENY LUDLUM

PIONEERING on the Horizons of Steel

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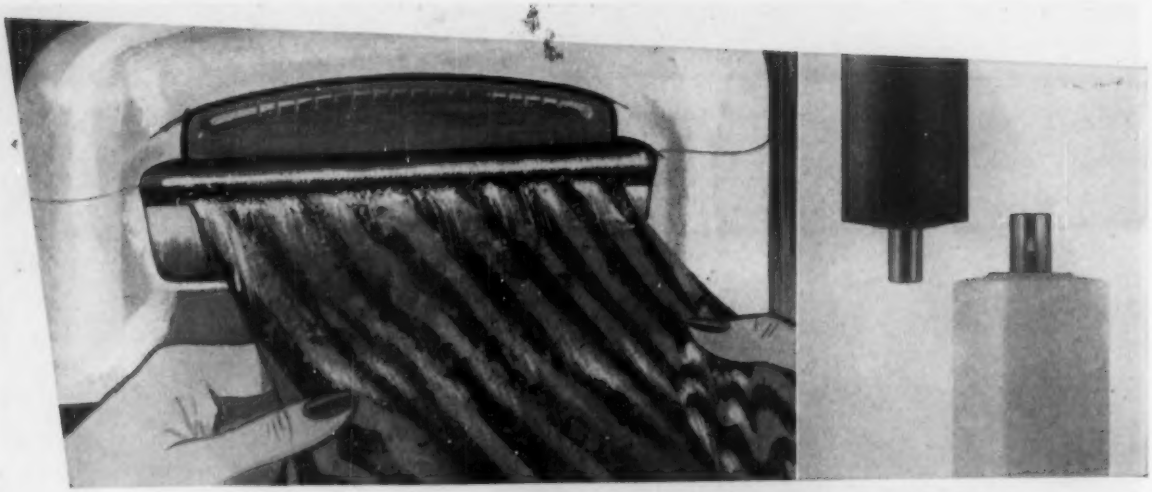

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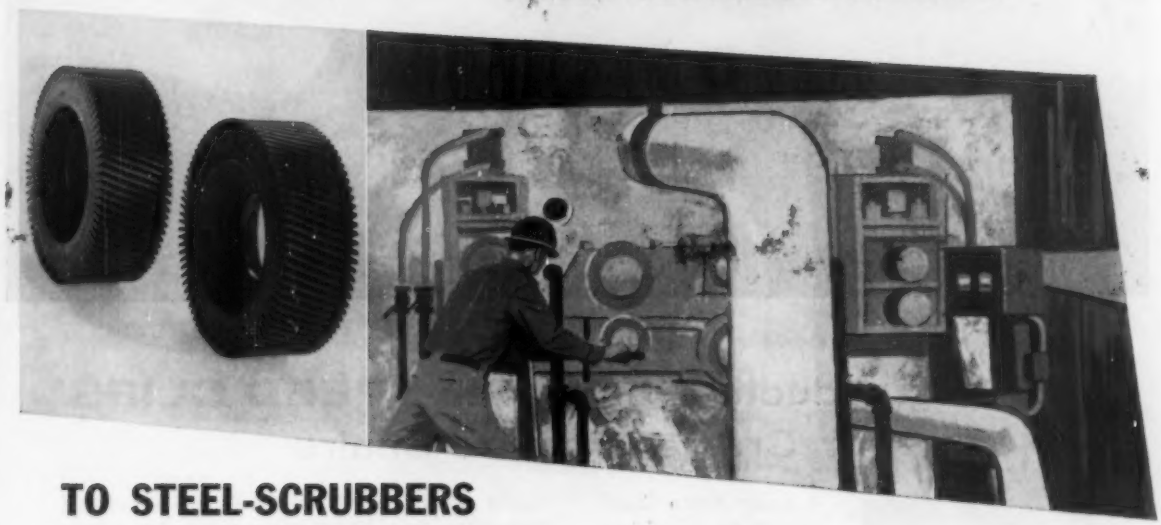

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Assembly costs on your product are likely to benefit greatly, too, if you'll enlist the aid of this Tinnerman team. You can arrange for a free FASTENING ANALYSIS of your product simply by calling in your nearby Tinnerman representative. You'll find him listed in the "Yellow Pages" and in Sweet's PD File under "Fasteners." Or write direct to:

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PRODUCT ENGINEERING HORIZONS

OCTOBER 10, 1960

THE STRAYED SHEEP

There's an old story about the new teacher who posed this problem in arithmetic: If there are 17 sheep in a pasture and one jumps the fence, how many are left? Johnny's answer: "None." Warned the teacher: "Johnny, if you take one from 17, sixteen are left." Said Johnny: "You may know arithmetic, Teacher, but you don't know sheep."

We've all heard of the bellwether and the Judas goat (the second is merely the abattoir equivalent of the first). These are leaders, trained to do a job, which they do. One leads the flock home safe; the other leads them to slaughter, but the willingness of the sheep to be led gives us our classic example of lack of personal initiative. In contrast, the sheep that jumps the fence is usually the untrained one, the offbeat character who insists upon trying something new. He's the originator in the sheep world, and the first one the sheep raiser disposes of, because he causes continual trouble. His life may be short but it is interesting.

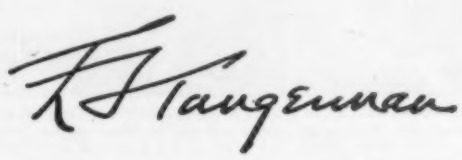
Among men (who deride sheep as shallow thinkers) there is a surprising amount of the same herd instinct. When there's a bellwether around, the crowd follows him safe to pasture—and they frequently follow the Judas goat just as readily. But, in sharp contrast to sheep, people seldom kick up their heels and jump the fence after the renegade.

Our innovators are quite certain that a breakout of pasture occurs far too seldom. They fight for acceptance, for even a meager following in most instances. And when they're proved right, we sheep are sheepish.

But this is all as it should be, if our society is to be a stable one. We must resist innovation for innovation's sake, or we'll be the victims of constant change, much of it unwise. By the same token, unless there is some change, the society becomes so stable it is static and on its way to disintegration.

Perhaps this is the one advantage of man over sheep—a little more caution, a little more care, a little less likelihood that he'll jump the fence. This forces the fence jumper to prove he's right, not just irresponsible. This attitude guards our society from mad flight, provides the brakes on the innovator so he'll have to fight his way to recognition.

Some innovations are lost this way, but accepted ones are proved by the same method.



Sudden Splash or Soaking Shower

won't stop a Wagner® DP Motor . . .

Wagner® Type DP Motors are doubly protected by rugged, corrosion-resistant cast iron frames and dripproof enclosures. Splashing or falling liquids, corrosive acids, salts, and alkalies can't stop their smooth operation. Designed to meet a wide variety of applications—including many that used to require splashproof motors—Wagner Doubly Protected Motors pack plenty of power into precious little space, are lightweight, long-lived, and pare downtime and upkeep costs to the bone. Simply put . . . they get the job done. Let your nearby Wagner Sales Engineer show you how these motors can be applied to your needs. Call him, or write for Bulletin MU-223.

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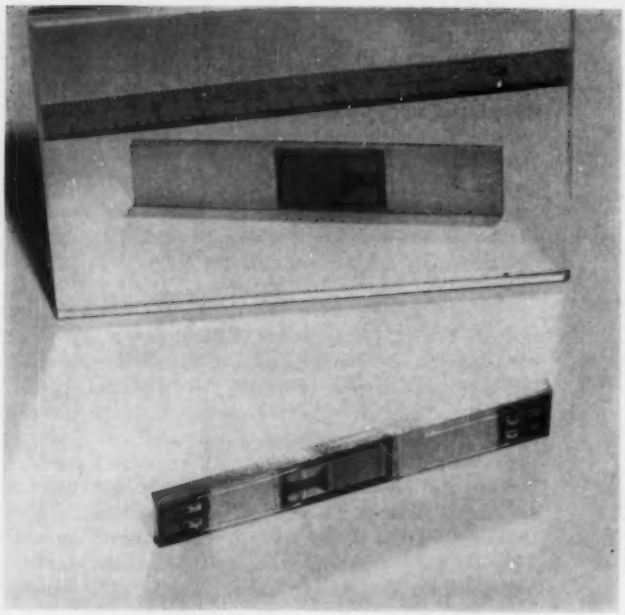
SLEEVE BEARING MODELS AVAILABLE... DP Motors are built in NEMA frame sizes 182 through 445U; 1 through 125 hp—1750 RPM—40°C; available with ball bearing construction as illustrated or steel-backed, babbitt-lined sleeve bearings. Larger motors (Type RP) are available through 1000 hp.

CAN BE RELUBRICATED... Original factory lubrication will last for many years in normal service, but openings are provided to permit the relubrication that adds years to motor life under severe conditions.

COOL RUNNING... Specially designed baffles direct cooling air through the motor to reduce stator temperature, thus increasing motor life. Blowers, cast as part of the rotor, move large volumes of air without noise or vibration.

WM60-20



introducing the Flexagage . . .

A DOUBLE-DECK RESISTANCE STRAIN GAGE

It's an assembly that effectively distinguishes bending strain from axial strain, but with its pair of metal-foil elements mounted on the same side of the structure being tested. This eliminates awkwardness of the conventional back-to-back arrangement. Here are first data, and equations for handling them.

Dr FELIX ZANDMAN, *director of research and development*
Instrument Div, The Budd Company, Phoenixville, Penna

Pictured above is a new type of strain transducer, especially designed to separate bending strain from the total strain at any point in shell or plate structures. Composed of two foil strain-gages mounted on opposite faces of a plastic spacer, the Flexagage (also called the bending-separator gage) overcomes a major instrumentation obstacle: Mounting of strain gages on both sides of the structure (back-to-back arrangement) is no longer necessary. This is because both gages are packaged in a single moistureproof, calibrated unit that mounts directly on the outside surface of the structure.

This simplification presents a number of important advantages over past methods (see *PE—July 6 '59, p 57*):

1. Only one side of the structure need be accessible, a vital point in structures like completed aircraft wings, small pressure vessels, etc., where accessibility to the inside side of the shell, plate, or skin is awkward.

2. Location problems are simplified. Tedious measurements for determining exact matching locations and orientations of back-to-back gages are eliminated.

3. With both gages mounted externally, fluid compatibility and hydrostatic correction are no longer problems. This latter effect can be serious, since initial zero reading as well as sensitivity of the internal strain gage in a back-to-back situation are functions of pressure.

4. Lead-wire problems are greatly simplified, particularly where one side of the structure is subjected to pressure. Lead wires under high pressures exhibit changes in inter-wire capacitance and in their own resistance. Having both gages outside also eliminates need for pressure-proof plugs, connectors, etc.

5. Gages that fail can be easily replaced. This is important in difficult-to-reach areas where the inside gage in a back-to-back setup must be installed before the structure is completely assembled. Gage failure here destroys all test data.

HOW THE NEW GAGE WORKS

The principle of the new transducer is simply an extension of the classic method of analyzing a strain situation with gages mounted back-to-back. The strain situations for the two cases are compared in the sketches on next page. For Case I, with one gage inside and one outside, the bending strain is the average of the two strain-gage readings; axial strain at the same point is half the difference of the readings. The method presupposes both gages are mounted exactly opposite each other and oriented in the same direction.

Case II shows both gages mounted outside the shell, plate, or skin—one gage on the surface, the second one

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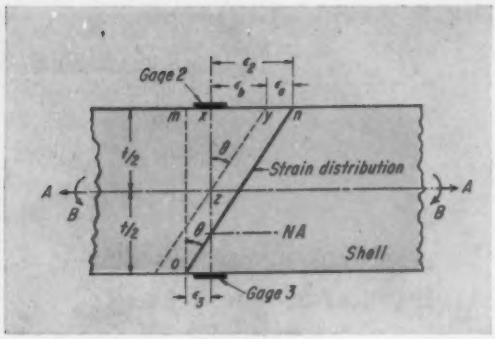


Case I

(Gages inside and outside)

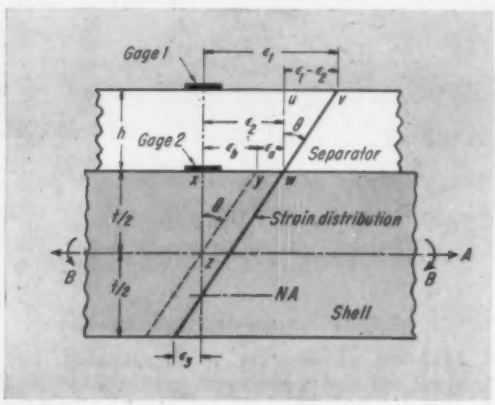
Triangles *xyz* and *mno* are similar, thus

$$\frac{\epsilon_b}{t/2} = \frac{\epsilon_2 + \epsilon_3}{t}$$

$$\epsilon_b = (\epsilon_2 + \epsilon_3)/2 \qquad (1)$$

Since $\epsilon_2 = \epsilon_b + \epsilon_a$

$$\epsilon_a = (\epsilon_2 - \epsilon_3)/2 \qquad (2)$$



Case II

(Both gages outside)

Triangles *xyz* and *uvw* are similar, thus

$$\frac{\epsilon_b}{t/2} = \frac{\epsilon_1 - \epsilon_2}{h}$$

$$\epsilon_b = \frac{t}{2h}(\epsilon_1 - \epsilon_2) \qquad (3)$$

$$\epsilon_b = K(\epsilon_1 - \epsilon_2)$$

Since $\epsilon_2 = \epsilon_b + \epsilon_a$

$$\epsilon_a = \epsilon_1 - K(\epsilon_1 - \epsilon_2) \qquad (4)$$

Nomenclature

- t Thickness of metal shall-plate-skin, in.
- h Distance between gages 1 and 2 on spacer, in.
- ϵ_1 Measured strain from gage 1 on outer surface of spacer, in./in.
- ϵ_2 Measured strain from gage 2 on inner surface of spacer, at outer surface of shell-plate-skin, in./in.
- ϵ_3 Measured strain at inner surface of plate-shell-skin, in./in.
- A Axial force at point in question or other load in the same plane, lb
- B Bending moment at point in question, lb
- ϵ_a Component of strain due to axial force, in./in.
- ϵ_b Component of strain due to bending moment, in./in.

above it by a carefully controlled distance, h. The plastic separator maintains this distance, but also bonds integrally to the structure so that it deforms as though it were part of it. If the strain distribution within the plastic separator is simply an extension of the linear strain distribution in the metal structure, then the two strain readings outside the surface establish the strain at all points beneath the surface. More important, these two strain readings will allow separation of bending strain from axial strain as shown by Eq (3) and (4). Note that the bending equation (3) contains both the metal thickness and the distance between the foil gages.

The question immediately arises: Is the strain distribution in the plastic separator indeed linear? It is, as has been proved by investigation of the reinforcing effects of PhotoStress (see *PE*—Sep '56, p 167) plastic. In these tests, strain gages were placed on top of the plastic coating, at the interface between plastic and metal, and on the uncoated side of the metal. All manner of combined bending and tensile loads were imposed on the structure, and under all of them the gage readings showed a linear strain distribution throughout the metal-plastic sandwich. This linearity was confirmed by photoelastic measurements within the coating itself. The bending-separator strain gage was conceived as a result of these tests on reinforcing effects.

REINFORCING EFFECTS

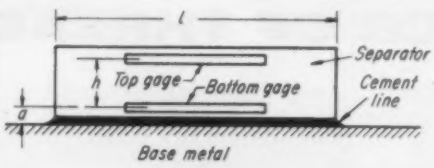
Attachment of any sort of strain-measuring system to a metal surface reinforces or stiffens that surface to some degree. The strain at the test location will be slightly less with the extra attachment than without it. The answer is to design the instrument so that this effect is held below a maximum not detrimental to engineering accuracy. For the bending-separator gage, there was the added problem of providing enough distance between the two foil gages to provide a significant difference in the signals from each for accurate measurement.

As they are now designed, the bending-separator gages have a maximum reinforcing effect of 2% and will yield a signal difference between gages of 50 to 100%. To achieve this, the width of bare metal to which the bending-separator gage is attached must be at least 7 times the separator width and the separation distance h must be at least 50% of the metal thickness. For this reason, a series of three gages, each with a different h-value, has been devised to cover a common range of metal-thickness (see table, opposite page). Thicker gages can be constructed if needed. For ratios of specimen- to separator-width less than 7, special corrections can be calculated.

MOUNTING

The new transducers are designed for mounting on any material with an elastic modulus greater than 6×10^6 psi (magnesium and stiffer materials). Stress analysis of a lower modulus material will have a higher error from stiffening. Mounting follows the same procedures as used with other metal-foil strain gages. Any solvent-free, room-temperature-curing adhesive will work. Examples are: contact cements like Eastman 910, or Budd Instrument Div Adhesive No. GA1, which cure in 1 minute; or epoxy adhesives like Armstrong Cork C-2. Metal surfaces may be cleaned with conventional aromatic chlorinated solvents

Data for the 3 Types of Bending-separator Gage



Gage Type	For Metal Thickness, in.	Dimensions, in. h	l	width	Resistance, Ohms	Max Voltage, volts
A	0.040–0.080	0.020	1½	⅜	120	12
B	0.080–0.160	0.040	1¾	⅜	120	12
C	0.160–0.320	0.080	2	⅜	120	12

(methyl chloride, ethylene dichloride, acetone, chloroform etc.), but the plastic material of the bending-separator gage should not be brought into direct contact with these solvents. The separator gage surface next to the metal may be cleaned with alcohol prior to installation.

SPECIAL PROBLEMS

Conventional rosette patterns may be set up, when directions of principal stresses are unknown, in the same manner as for conventional strain gages. It is important to note, however, that the Flexagage itself should not be trimmed to gain space advantage. The length dimensions given in the table were carefully established to distribute the strain smoothly throughout the separator and eliminate end effects.

Temperature can influence the results in several ways. (1) resistance heating can soften the bond between the foil gages and the plastic separator, causing creep. This has been designed for by making the spacer of a heat-conducting plastic carry this internal heat away to the base metal. (2) Mismatch of thermal-expansion coefficients between base metal and plastic separator can induce thermal strains if ambient temperature changes appreciably. Dummy gages mounted on the same material can be used to correct for this effect.

Maximum operating temperature for the bending-separator gage is controlled by the temperature resistance of the plastic separator block, and has not yet been precisely determined. So far, the new gages have been used up to 110 F with no loss of accuracy.

Nonlinear strain distributions through the metal thickness are a difficult problem and usually call for theoretical analysis or three-dimensional photoelastic techniques. A good example is the thick-walled cylinder, where the hoop strain distribution, from point to point along a radius, is hyperbolic. In such a case, the bending-separator gage can be laminated to include a third metal-foil gage in the middle. This gives three strain points, and allows a fair distribution curve to be drawn. This should be refined further by placing another strain gage on the interior surface for another boundary point. Here, the conventional back-to-back method cannot give accurate results.

Very thin metal structures require a special correction because here the thickness of the mounting cement and the thickness of the epoxy cover over the bottom gage become significant. For these cases, a new constant K for Eq (4) must be employed

$$K' = \frac{t/2 + a}{h}$$

where a is the cement line thickness plus 0.001 in., the thickness of the epoxy cover over the bottom foil gage (a is usually 0.002 in.). Values of h are given in Table I. Cement thickness can also be measured by deducting the gage thickness from the installed height of the gage.

For REPRINT of above article, just check P64 on one of the Reader Service cards in this issue.

ABOUT THE AUTHOR

Felix Zandman, holder of many patents in the stress-analysis field, was recently decorated by France with its Order of Merit for Research and Invention. The present article, his fourth contribution to PRODUCT ENGINEERING, is latest of many he has published here and abroad. Before coming to this country he was head of New Product Research Section at the jet-engine firm, S.N.E.C.M.A., as well as associate professor at the French Institute of Aeronautics. He holds MS degrees in mechanical engineering and in physics, and a doctorate in physics from the Sorbonne.

Dr Zandman's interest in stress analysis dates back to his doctoral work. Using photoelastic plastic models to measure strain, he found his results wouldn't check with strains on the actual part. This led to the conception and successful development of PhotoStress, which reads strain from a bi-refringent plastic bonded directly on the surface of a metal part.

With The Budd Company since 1957, he conceived the Flexagage as a result of his further work on reinforcing effects of PhotoStress. Further development of the new gage was carried out at Budd's Instruments Div by Dr Jerome Catz of MIT.

EDITOR'S NOTE: For other articles covering stress-analysis techniques for design:

Survey Method Evaluates Residual Stresses in Gears, Sep 14 '59, p 84—Details on test method to survey which hardening treatment and combination of materials give highest residual stresses in gears.

Acoustoelasticity, July 20 '59, p 56—Polarized high-frequency sound can measure residual as well as applied stresses on metal parts. New method eliminates need for plastic models required by the polarized-light photoelastic technique.

Finding Stresses in a Pressure-vessel Head, July 6 '59, p 57—How to compute biaxial stresses where head and shell join—without having strain gages inside the vessel. Discusses both spherical and elliptical heads.

Photostress Analysis, Mar 2 '59, p 43—Describes latest developments in the photoelastic technique, with emphasis on torque analysis.

How to Measure Principal Stresses, Oct 14 '57, p 101—Ways to get the most out of strain-gage analysis. Distribution diagrams for pressure-vessel stresses are given, along with basic design equations.

Three-dimensional Photoelasticity, July '57, p 135—Discusses application of latest materials and techniques to pressure vessels of unusual shapes.

VIBRATION RESISTANCE OF THREAD-

New test method rates how various ESNA-type locknuts perform during vibration, and how they compare with plain nuts.

K R BRONSON, *head of research*
C C FARONI, *chief product engineer*
Elastic Stop Nut Corp of America, Union, NJ

Many different types of thread-locking devices can satisfy the military's vibration-resistance specifications, AN-N-5 or MIL-N-2052 (ASG). But when an application requires maximum resistance to vibration, tests covering those specifications cannot give comparable data for various types of nuts. This is because:

- The test is not reproducible.
- It is limited in range of bolt sizes, and to nuts which are not seated.

In the past, most vibration tests were conducted with no preload in the bolt, because existing test procedures could not satisfactorily produce loosening vibrations in a preloaded connection typical of those encountered in service. Furthermore, loss of bolt tension results from many factors, including roughness of mating surfaces, wear, corrosion, yielding, lack of squareness, burrs and other factors. The elastic elongation of a bolt due to assembly torque is between 0.001 and 0.003 in./in. of length. Consequently, it takes only a small amount of wear, yielding of high spots on the bearing surfaces or yield of the bolt due to overload, to cause the loss of all, or most of the bolt tension.

This type of reasoning has favored the evaluation of the effectiveness of self-locking nuts solely on the basis of locking torque. While such tests will conveniently check the quality of manufacture, they do not provide information on ability of the nut to resist vibration. In some types of locknuts, a very small amount of axial thread distortion produces high initial torques. Under vibration these high spots quickly wear to where little, if any, locking torque remains. A reliable vibration test shows this up quickly; a torque test does not.

One necessary function of a locknut is to stay on the bolt and prevent the joint from coming apart, even when all bolt tension is lost. This represents a condition in which the locking device alone keeps the nut from turning. Also, nuts are frequently reused after having been removed for maintenance or adjustment, and the equipment is expected to function satisfactorily. Therefore, tests should simulate this condition, by running the nut on and off the bolt several times before vibration testing

Our New Vibration Test

To overcome these shortcomings we developed a reproducible vibration test method in which:

- Test conditions can be made severe enough to shake any locknut loose, thus evaluating performance over a wide range of sizes and conditions.
- The conditions can be controlled to reveal a pattern of behavior for various thread-locking devices under different test conditions.
- Bolts can be preloaded or run loose without any tension.
- Effect of torque, tension, surface conditions and wear can be evaluated.

The test fixture shown here has elongated slots in which bolts and nuts being tested are free to move up and down in the slot. The fixture is mounted on the platen of a Sonntag fatigue machine and vibrated vertically; the resulting impacts are the source of the loosening forces. Slots are designed so the vertical movement (fixture clearance) is ¾ in. for all bolt sizes. The tests are made at a frequency of 1800 per minute with a vibration amplitude setting of 7/16 in. Number of cycles in the test run is indicated on the machine. Any number of specimens up to 5 can be tested in one run without affecting test results.

These bolts are assembled by two methods illustrated, facing page. Method A for loose-connection tests, simulates loss of bolt tension caused by wear, roughness or yielding. Method B, for tight-connection tests, can produce various degrees of bolt tension. Method A is best for evaluating the locking effectiveness of self-locking nuts, but Method B can be used for comparing free-running locknuts, plain nuts and lockwashers, and any other methods of locking a nut on a bolt. Bolts, washers and cylinders are selected so that all specimens in any one test series are identical.

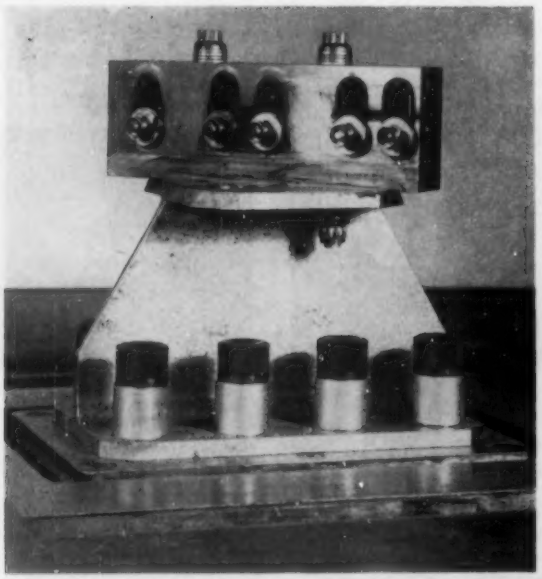
Each test is continued until all specimens fail either by the nut running off the bolt or breaking of the bolt. Exceptions are when one specimen in a series outlasts all the other specimens by a wide margin, in which case the test is stopped.

Factors Affecting Loosening

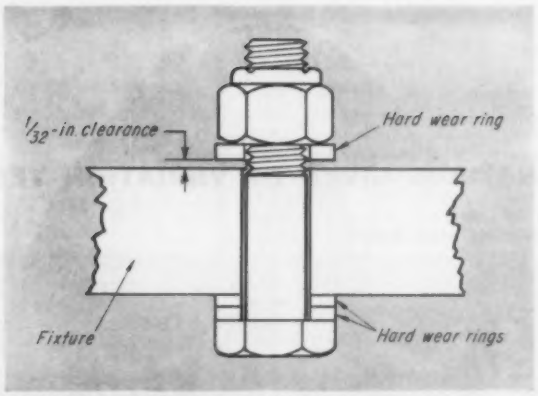
Since different test conditions are controllable, they can evaluate factors that affect loosening of nut and bolt:

- Relationship between assembly torque and bolt tension.
- Heat treatment as it affects surface conditions.
- Lubrication.
- Effectiveness of a locking element, when used.
- Thread fit of nut and bolt.

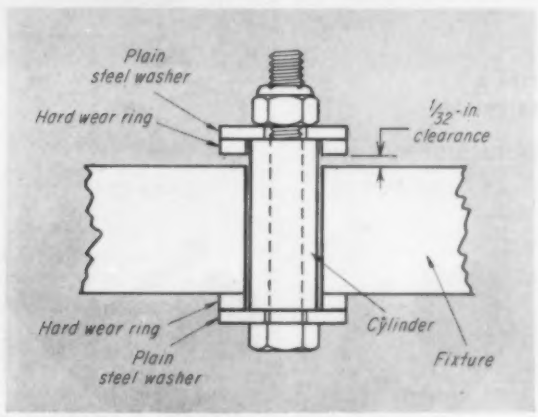
LOCKING DEVICES



IN TEST FIXTURE above, bolts and nuts move up and down under adjustable vibration force to give uniform impact to all five specimens. Either of two mounting methods can be used, as shown in sketches.



METHOD A—for loose-connection tests.



METHOD B—for tight-connection tests.

Torque-tension Relationship

To determine the effect on bolt and nut, loosening tests were run with plain nuts. Tests were made with a tight connection, using hard-steel cylinders; machined, carburized and hardened washers; and SAE Grade 8 bolts. Both ends of the bolt were ground parallel to permit accurate length measurements for calculating bolt elongation.

Three series of tests, at 40,000-, 44,000-, and 50,000-psi bolt tension, were run with 5 bolts in each. Results showed that bolting torque is a major factor. For example, at 40,000-psi bolt tension, 4 out of 5 bolts came off in 3000 or fewer cycles. The fifth, which stayed on until the test was stopped, had required the highest installation torque. This was substantiated by the tests at 44,000-psi tension, where 4 out of 5 stayed on the bolts beyond 100,000 cycles, and the one that came off at 3000 cycles had required the lowest installation torque. The tests at 50,000-psi also showed the need for high torque; however, the increased tension here caused 2 out of the 5 bolts to break before the nuts came off. This showed that while high torque is desirable, the attendant high tension limits fatigue life of the bolts under impact and vibration. In conntrast, it is generally accepted that high tension improves fatigue life when external loads are smoothly cycled.

Effect of Surface Conditions

1. Heat treatment can change the torque-tension relationship—higher torque is needed to give bolt tension. For example, a series of bolts were placed in an oven at 900 F for ½ hr. These bolts required 110 to 180 lb-in. of torque to produce 40,000-psi bolt tension, while those without such heat-tinting required only 80 to 110 lb-in. to give the same tension. All 5 heat-tinted specimens remained bolted for a minimum of 100,000 cycles as compared to 3000 cycles maximum for 4 out of 5 specimens without heat-tinting. This means the larger installation torque was a significant advantage.

2. Lubricating the threaded surfaces of the bolt and nut produces an effect opposite to heat-tinting. This was shown in a series of tests using graphite petroleum Spec MIL-T-5544 A-(ASG) without any heat-tinting. The 5 specimens in this series required only 40 to 50 lb-in. torque to produce 44,000-psi bolt tension. Under vibration, 4 out of 5 were off in less than 5000 cycles, and the fifth came off at 73,000 cycles. This showed high torque is essential, but lubricated threads make nuts fall off faster.

Results of these tests are shown in Table I, p 61. The tensions are calculated based on length measurements. The notations (TS) indicate test was stopped, and (BB) indicates that the bolt broke. On all other tests without such notations, the nuts came off the bolts.

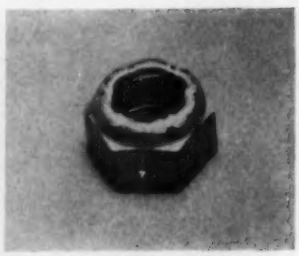
Effectiveness of Locking Element

To determine the relative vibration resistance of various types of thread-locking devices a series of tight-connection vibration tests were run. Cadmium-plated ¼-28 NF-3

RATINGS GIVEN BY VIBRATION TESTS

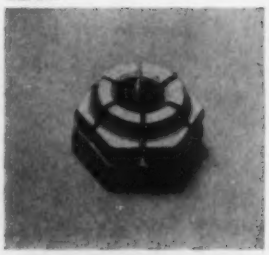
NONMETALLIC INSERT

TYPE A
RATING 100



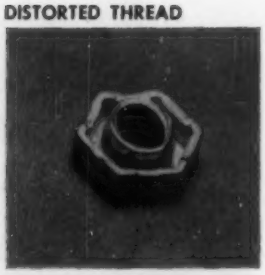
B
43

BEAM



C
53

DISTORTED THREAD



T
19

CASTELLATED NUTS WITH

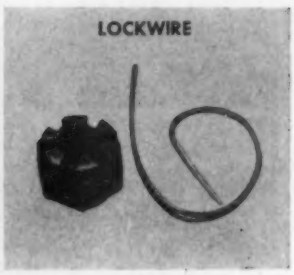
ROLL PIN

TYPE S
RATING 38

COTTER KEY

Z
18

LOCKWIRE



O
8

PLAIN NUT WITH

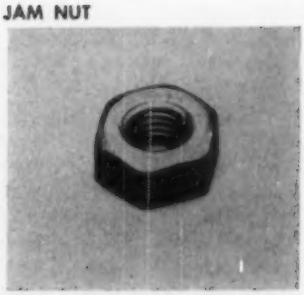
SPRING LOCKWASHER

TYPE Y
RATING 5

PLAIN NUT

L
1

JAM NUT



TYPE Q
RATING 1

TIGHT-CONNECTION VIBRATION TESTS of ¼-28 bolts with 10 different types of nuts gave highest rating to nonmetal insert nut. Comparison is shown above. Loose-connection vibration tests, where locking device of the nut alone keeps it from turning, gave a similar pattern of performance. For a number of specimens of the first 4 types above, the loose-connection performance of ⅛-20 bolts gave the following ratings: Type A-100, B-32, C-42, and T-14. However, in comparison with tight-connection, all nuts in the loose-connection tests came off much sooner.

TABLE I—EFFECT OF TORQUE, TENSION AND SURFACE CONDITIONS ON PLAIN-NUT LOOSENING

Surface Treatment	Tension, psi	Torque, lb-in.	Cycles on Bolt
None	40,000	80	2,000
None	40,000	80	3,000
None	40,000	90	2,000
None	40,000	80	1,000
None	40,000	110	30,000 (TS)
Heat-tinted	40,000	140	100,000
Heat-tinted	40,000	180	100,000
Heat-tinted	40,000	120	145,000 (TS)
Heat-tinted	40,000	130	145,000 (TS)
Heat-tinted	40,000	110	145,000 (TS)
None	44,000	100	125,000 (TS)
None	44,000	80	3,000
None	44,000	100	116,000 (BB)
None	44,000	100	125,000 (TS)
None	44,000	110	125,000 (TS)
Lubricated	44,000	40	2,000
Lubricated	44,000	50	73,000
Lubricated	44,000	45	1,000
Lubricated	44,000	50	2,000
Lubricated	44,000	45	2,000
None	50,000	130	87,000 (BB)
None	50,000	120	100,000 (TS)
None	50,000	100	100,000 (TS)
None	50,000	120	71,000 (BB)
None	50,000	130	100,000 (BB)

NOTES
(TS) Test stopped
(BB) Bolt broke

SAE STANDARD FOR BOLTS AND NUTS

SAE Handbook gives specifications for proof load, tensile strength, hardness, and material with heat treatment for grades 0 to 8. Details for minimum requirements for each grade, method of testing, and standard identification markings are also given. Grades 0 and 1 are ordinary commercial, made with open-hearth, electric furnace or Bessemer steel. For all other grades, open-hearth or electric-furnace steel is specified. Each grade must conform to specified proof loads and tensile strengths, although no limitations are placed on the composition of the steel.

TABLE II—EFFECT OF BOLT FIT ON TIGHT-CONNECTION VIBRATION TEST

Nut Type	Cycles	
	Class 3 Bolt	Class 2A Bolt
Distorted thread (G)	8,000	5,000
Jam nut (Q)	12,000	6,000
Nonmetal insert (W)	201,000	96,000

bolts with tensile strength of 125,000 psi were used and the cylinders were hardened and ground. The washers used were soft, standard commercial grade. All nuts were assembled with 70 lb-in. torque, and the tests were continued until all the nuts came off. The types of nuts used and their relative performance ratings are shown above.

In calculating the ratings for each design the minimum life in a group of specimens was used since this is the significant figure if no loosening during equipment life can be tolerated. Results show that resilience and dampening of the nylon insert type offers greatest resistance to vibration. The beam type offered next best performance, which was considerably better than the elliptical-distorted thread type. Performance of the various types of locking devices on castellated nuts and their comparison with the nylon insert type shows that resilience of the locking mechanism plays an important part in resisting vibration. Another significant finding is that the plain nut, with or without a spring lockwasher, showed a rating of only 1% compared to the nylon insert nut.

Loose-connection tests are useful in determining the effectiveness of the thread-locking device after all bolt tension is lost. The results from a series of these tests, indicate that the performance pattern of the various types is the same as in the tight-connection test. They show that the resilience of nylon inserts or beam deflections are more effective than distorted thread sections, which soon wear down under vibration.

Effect of Thread Fit

To determine the effect of thread fit, several designs of nuts were tested on ¼-28 bolts with both Class 3 and Class 2A fits. Tests on a number of specimens of each design showed that Class 3 fit was definitely better for all designs.

EDITOR'S NOTE: For other recent articles on fasteners see:

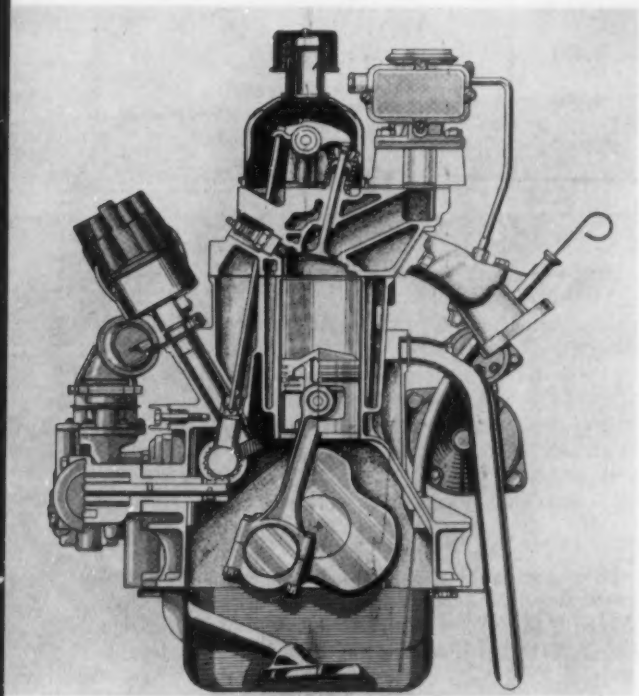
Test Results Guide High-temperature Design of Bolted Assemblies, Sep 30 '57, p 79—Recommends materials for bolts and structures up to 1350 F, gives test results for computing effects of heat expansion.

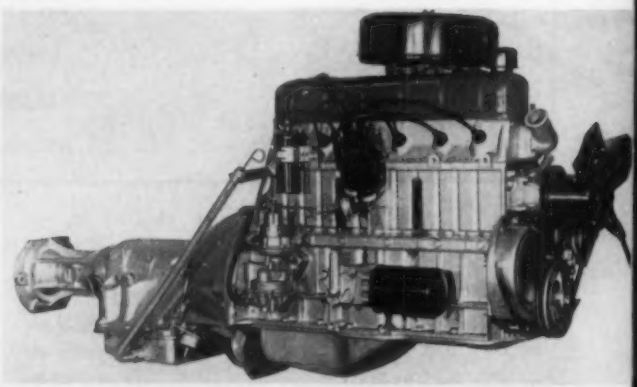
Assembly Methods—an Engineering Roundup, June 8 '59, p 91—Diagrams for sheetmetal fastening, die-cast parts, glass, plastics, spring joints, brazed joints, and detailed checklist of additional information on assembly methods and materials.

RAMBLER'S "CLASSIC"

Die-cast engine lightens this compact

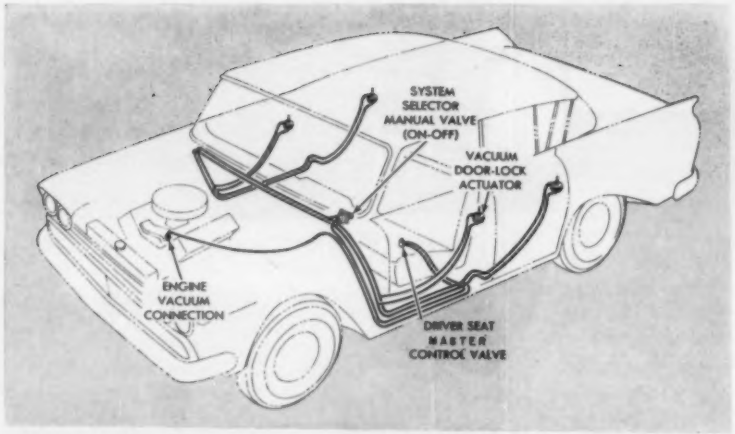
Aluminum block in the '61 Rambler 6-cylinder engine is 80 lb lighter than its cast iron predecessor. Driver-controlled door-locking system is a featured option for added safety and convenience





ENGINE BLOCK is one-piece diecasting of S12A aluminum-silicon alloy. This provides required hardness plus controlled temperature expansion. The 67-lb block has 53 lb of Al and 14 lb of iron cast in one shot at 8000 psi. Cylinder liners are centrifugally cast iron, chemically and mechanically bonded to the block. Water passages in block are open at top, as required by die-casting method, and mate with water passages in the head. Raised piston-crown provides wedge-shape combustion area to control flame propagation and permit an 8.7:1 compression ratio with regular fuel. Steel stampings are used for the valve cover, timing-gear case and oil pan.

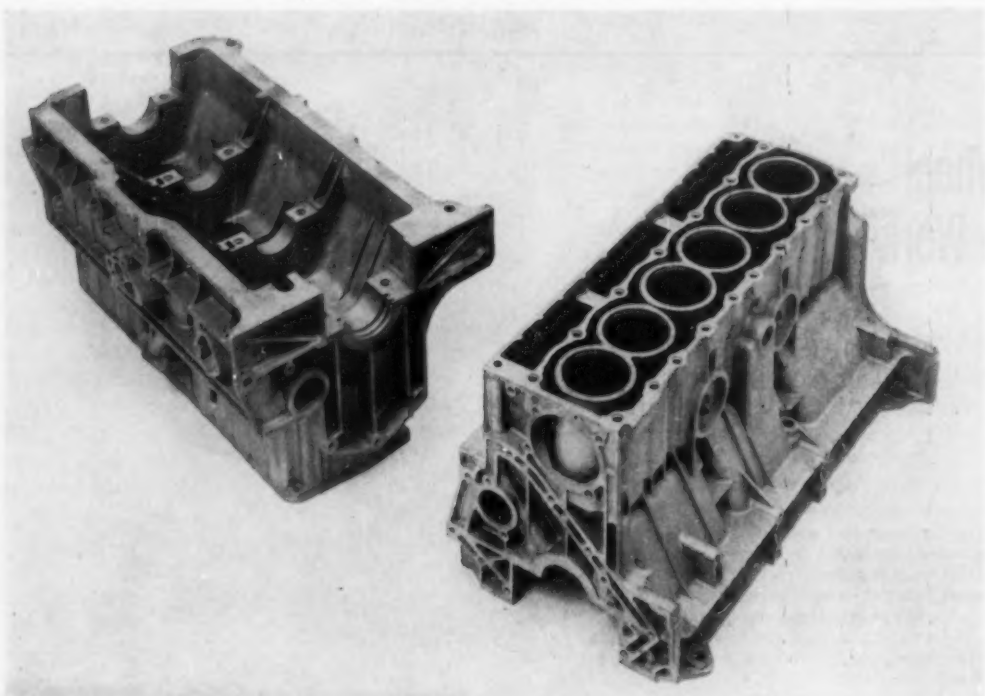
Overhead valves are actuated by hydraulic valve lifters through pushrods and rocker arms. External oil pump is driven off the cam shaft and mounts a full-flow, cartridge-type oil filter on front of its housing. Downdraft carburetor supplies the combustion mixture to each cylinder through intake passages cast in the cylinder head. Combined vibration-damper-pulley mounted on nose of the crankshaft drives the generator, water pump and fan.


SYSTEM SELECTOR MANUAL VALVE (ON-OFF)
VACUUM DOOR-LOCK ACTUATOR
ENGINE VACUUM CONNECTION
DRIVER SEAT MASTER CONTROL VALVE

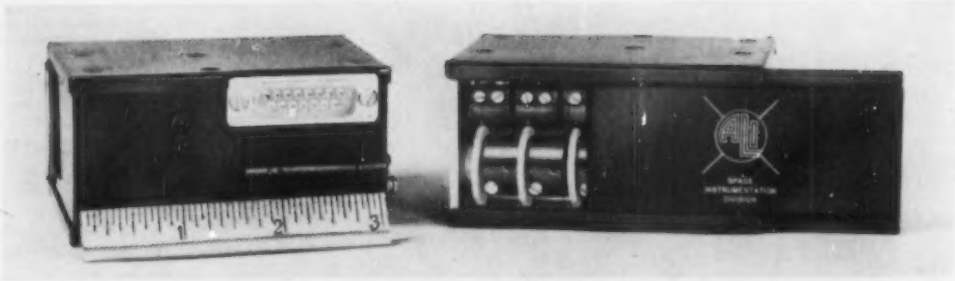
POSITIVE DOOR-LOCKING SYSTEM is controlled by a manual selector on the dashboard. Vacuum actuators at each door control individual locks on front and rear doors. Tube connected to intake manifold runs to a master valve beneath the driver's seat and then to a selector valve on the dashboard. System cannot operate until driver's weight trips the master valve.

RAMBLER CLASSIC SPECIFICATIONS

Wheelbase	108 in.
Over-all Length	189.8 in.
Over-all Height	57.3 in.
Over-all Width	72.4 in.
Weight (dry)	2950 lb
Tread, front	57.75 in.
rear	58.0 in.
No. of Cylinders	6 or V-8
Bore & Stroke	6—3⅛ x 4½ in.
	V-8—3⅛ x 3¼ in.
Displacement	6—195.6 cu in.
	V-8—250 cu in.
Compression Ratio	6—8.7:1
	V-8—8.7:1
Torque	6—180 lb-ft @ 1600 rpm
	V-8—245 lb-ft @ 2500 rpm
Brake-horsepower	
	6—127 @ 4200 rpm
	V-8—200 @ 4900 rpm
Tire Size	6.50 x 15
Brake Area	153.8 sq in.
Turning Dia.	37.25 ft



PS . . . Hailed by American Motors as "the automobile that touched off the compact-car revolution," Rambler shows an awareness in its "Classic" series of growing competition. Classic can be had powered by a six or V-8; and comes in three styles—4-dr sedan and the 2- or 3-seat station wagons. Die-cast engine resulted from cooperative R and D program between Doehler-Jarvis Div, National Lead Co, Toledo; and American Motors Corp, Detroit, who produce the entire car.



Worm Gear Makes This Timer Precise

A screwdriver is all it takes to adjust the cams in this lightweight timer. Settings are accurate within 0.1% of the total period.

PS . . . Miniature adjustable sequence timer Model 4-23 has a time span of 1 sec to 45 min., is produced by Acton Laboratories Inc., Acton, Mass.

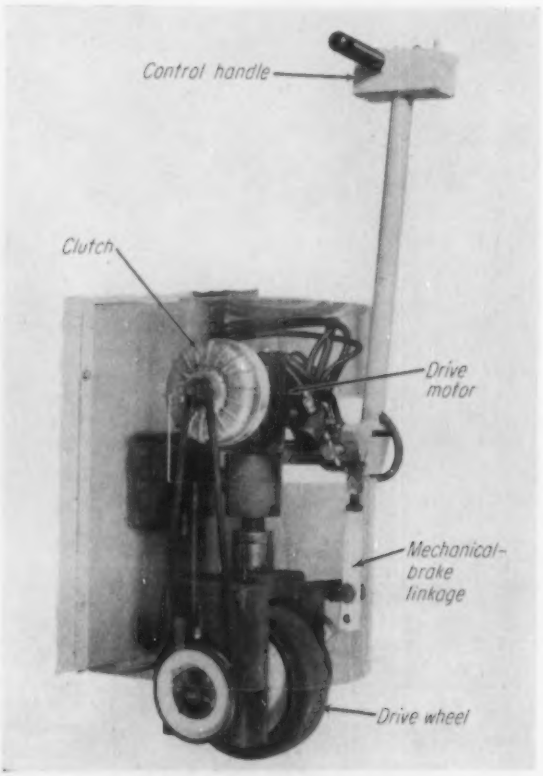
MOTOR-DRIVEN TIMER uses rotating cams to trip switches at the desired time. Nylon cam has geared hub which fits into a collar locked to timer shaft. Brass screw in collar locks cam and collar together and functions as an adjusting worm. Rotating the brass screw rotates the nylon cam for precise time adjustments.

"Fifth Wheel" Does the Work

It's a compact electric drive that eliminates manual handling of heavy, rolling loads. Unit moves vertically to follow contour of floor.

DRIVEWHEEL carries only the weight of the propulsion unit. It rides up and down freely to compensate for floor irregularities, maintaining constant traction between wheel and surface. Pivoted control handle permits steering with minimum effort. Three pushbuttons in handle provide fingertip control of forward and backward movement, plus braking. Moving the handle to the vertical position applies the mechanical brake.

PS . . . Dyna-Drive is available in either 3000- or 8000-lb capacities. Battery-operated 12-v dc motor powers the drive-wheel through either a fluid drive or centrifugal clutch. Power unit is produced by Colson Corp, Chicago.



Better Way to Place Sliderule Decimal Point

"Supes" and "subs" eliminate serious errors—and reduce computation time.

HARVEY S PARDEE, *consulting engineer, Sunland, Calif*

There are systematic and generally accepted ways of calculating with a sliderule, but when it comes to a method for placing the decimal point in the result, you can pretty much take your pick. If you trust your mental arithmetic, you probably make a quick estimate while considering the risk of order-of-magnitude errors. If you are fastidious, you may assign a logarithmic characteristic to each factor and, compute characteristic of the answer.

The following aid incorporates the best features of both methods. It requires some mental arithmetic but most of the bookkeeping is handled by small numerals that replace the decimal point to keep tabs on powers of 10. About an hour's study and practice should give you facility with the method and confidence in the result.

First, rewrite the factors as numbers between 1 and 10. But instead of the decimal point itself, actual position of that point is indicated by a small numeral written between the first and second digits. A superscript n indicates that the true decimal point is n places to the right; a subscript n indicates that it is n places to the left.

$$1000 = 1^{3}0$$
$$0.001 = 1_{3}0$$
$$2.67 = 2^{0}67$$

Numbers with only one significant figure are written with a zero following the decimal point to avoid confusion between superscripts and exponents. In our work, we have found it convenient to shorten the names of the notations to supe (pronounced "soup") and sub. Thus $2^{3}4$ is spoken "two, supe-3, four" and $6_{2}3$ is spoken "six, sub-2, three."

Efficiency of the notation is seen by comparing it to the other methods of writing numbers. They require 4 to 7 more characters to present the same information.

$23000 = 2^{4}3 = 2.3\times10^{4} = 2.3\times10{,}000 = 23$ thousand
$0.000{,}000{,}3 = 3_{7}0 = 3.0\times10^{-7} = 3/10{,}000{,}000 = 3$ ten-millionths

Multiplication and Division

In computation, supes are treated as positive quantities, subs as negative. These are summed for multiplication and subtracted for division. The following example shows details of the procedure found to give sure results and greatest speed.

$$R = \frac{0.00102 \times 33.4}{4.66 \times .872 \times 95.5}$$

(1) write: $1_{3}02 \times 3^{1}34 / 4^{2}66 \times 8_{1}72 \times 9^{1}55$
(2) with sliderule, compute: $R = 878$, without decimal point
(3) mentally compute: $(1)(3)/(5)(9)(10) = 3/450 = 0.007 = 7_{3}0$
(4) sum supes and subs: $-3 + 1 - (0 - 1 + 1) = -2$
(5) add sub (or supe) of answer from step (3):
$$-2 + (-3) = -5$$
$$R = 8_{7}78 = 0.0000878$$

Occasionally, (about one time in 50) the first significant digit of the mentally computed answer in (3) will be a 9 and the first significant digit in (2) will be a 1. If so, add 1 to the result in (5). If the reverse happens—9 in (2) and 1 in (3)—subtract 1 from (5).

The following example (one of the special cases described above) shows computation in workbook form.

$$R = \frac{(0.00638)(842)}{4.82}$$
$$(6_{3}38)(8^{2}42)/4^{0}82$$
$$R = 1^{0}117 = 1.117$$

Powers and Roots

Numbers with exponents can also be expressed in this notation. The supe of a power is simply the product of the supe and the exponent (and correspondingly for the sub). Add to this the supe of the mentally computed power of the first digit. For example:

(1) $R = (653)^{2} = (6^{2}53)^{2}$
(2) with sliderule: $R = 427$, without decimal point
(3) mentally compute: $6^{2} = 36 = 3^{1}6$
(4) multiply supe times exponent: $2 \times 2 = 4$
(5) add supe from (3): $4 + 1 = 5$
$$R = 4^{5}27 = 427{,}000$$

When the power is one factor in an expression, the workbook looks like this:

$$R = \frac{(723)(0.095)^{3}}{2.71}$$
$$(7^{2}23)(9_{2}5)^{3}/2^{0}71$$
$$R = 2{,}285 = 0.2285$$

Roots are handled the same way except that when rewriting the number the supe must be placed so that it produces an integer (or zero) when multiplied by the fractional exponent. The supe of the result is supe of the number divided by the root. For example:

$$\sqrt[3]{0.0037} = (3_{7}7)^{1/3} = 1_{2}55 = 0.155$$
$$\sqrt[3]{0.37} = (370_{3})^{1/3} = 7_{1}19 = 0.719$$

Or, as a part of a longer expression:

$$R = \frac{(0.653)(803)}{\sqrt[3]{8200}}$$
$$(6_{1}53)(8^{2}03)/(8^{3}2)^{\frac{1}{3}}$$
$$R = 2^{1}60 = 26.0$$

DESIGN NOMOGRAPHS

THE EASIER WAY

Here's a method that provides an automatic solution. Once the equation has been put into the proper determinant form the nomograph is, to all intents and purposes, done. Any careful draftsman can follow your instructions to produce a final large-scale drawing without guesswork.

C R GLANVILLE, *project engineer, Wells Survey Inc, Tulsa, Okla*

Determinants offer the most comprehensive method of constructing nomographs—but for some reason the method has been pretty well ignored in the literature. The determinant method is particularly attractive because it determines the position, shapes and scales of the nomograph stems (or lines) by simple algebraic manipulations. Layout and drafting are greatly reduced compared to the requirements of geometrical methods.

BASIS OF THE METHOD

Let us assume that

$$A_1\,(x_1, y_1)$$

and

$$A_2\,(x_2, y_2)$$

are two points given by their coordinates with reference to a rectangular system of axes. The equation of the line through these points is

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}\,(x - x_1) \tag{1}$$

where

$$m = \frac{y_2 - y_1}{x_2 - x_1} \tag{2}$$

is the slope of the line.

If we multiply Eq (1) by

$$(x_2 - x_1)$$

and then transpose all the terms to the left-hand side and simplify, the result

$$xy_1 - xy_2 - x_1y + x_1y_2 + x_2y - x_2y_1 = 0$$

is equivalent to

$$\begin{vmatrix} x & y & 1 \\ x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \end{vmatrix} = 0 \tag{3}$$

Therefore, Eq (3) represents the equation of a line expressed in determinant form. It is satisfied by

$$x = x_1,\ y = y_1$$

$$x = x_2,\ y = y_2$$

so that the line goes through the two points A_1 and A_2.

Three points:

$$A_1\,(x_1, y_1)$$

$$A_2\,(x_2, y_2)$$

$$A_3\,(x_3, y_3)$$

therefore determine a straight line if, and only if,

$$\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = 0 \tag{4}$$

A plot of a line determined by Eq (4) is shown in Fig 1. It is important to note that the positions of the points are obtained by letting the elements of the first column represent displacements on one axis (in this case, the X axis) and the elements of the second column represent displacements on the other axis (in this case, the Y axis).

Of course, any number of lines are determined by Eq (4) for any number of points as long as the equation is satisfied. The points

$$x_1, y_1$$

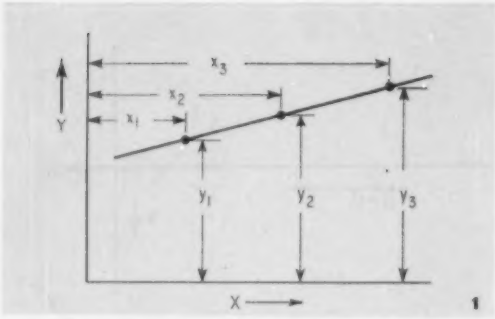
$$x_2, y_2$$

$$x_3, y_3$$

can therefore represent variables or functions of variables which satisfy the equation. Furthermore, if each point is allowed to represent functions of not more than one variable,

$$\begin{vmatrix} f_1(u) & f_a(u) & 1 \\ f_2(v) & f_b(v) & 1 \\ f_3(w) & f_c(w) & 1 \end{vmatrix} = 0 \tag{5}$$

then scaling for three variables, u, v and w, can be provided on stems as shown in Fig 2. The positions, shapes and scales of these stems are determined by letting the first column of Eq (5) represent the displacement on one axis as a function of a variable and letting the second column of Eq (5) represent the corresponding displacement on the other axis as a function of the same variable. The derived graph is a nomograph because any straight line intersecting the u, v and w stems is a solution to Eq (5).



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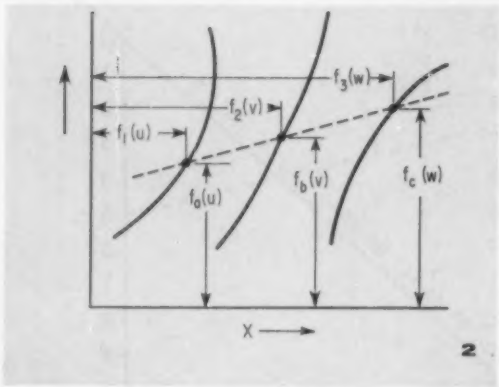

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STEPS IN NOMOGRAPH CONSTRUCTION

Four steps are used in constructing a nomograph of an equation by the determinant method:

(a) Equation is simplified and transformed into a function of three variables equal to zero.
(b) Function is expressed as a determinant.
(c) Determinant is transformed into the nomographic form given by Eq (5).
(d) Scale ranges are assigned to the variables, and the nomograph is constructed using the information given in the nomographic form of the determinant.

It is frequently necessary to make adjustments in the first determinant, satisfying step (c) so positions and scale ranges of the nomograph stems will be in the most workable form.

EXAMPLES OF NOMOGRAPH CONSTRUCTION

Elementary examples will be used to illustrate the mechanics of nomograph construction.

Sum of Two Variables

Let us first construct a nomograph of the general equation for the sum of two variables,

$$z = x + y \tag{6}$$

Since this equation is already a simplified function of three variables, we need only equate it to zero to complete step (a):

$$z - x - y = 0 \tag{7}$$

In step (b), we express the function as a determinant:

$$z - x - y = \begin{vmatrix} z & 1 & 1 \\ x & 1 & 0 \\ y & 0 & 1 \end{vmatrix}$$

In step (c), we may transform the determinant into the nomographic form by adding the elements of column 2 to the ele-

PROPERTIES OF DETERMINANTS—A BRIEF REVIEW

The symbol

$$\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}$$

is used to denote the quantity

$$a_1b_2 - a_2b_1$$

This particular symbol is called a determinant of the second order, and the numbers

$$a_1, \quad a_2, \quad b_1, \quad b_2$$

are its elements. Its rows are

$$a_1b_1 \text{ and } a_2b_2$$

Its columns are

$$a_1\ a_2 \text{ and } b_1\ b_2$$

Similarly, a determinant of the third order is symbolized

$$\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}$$

Its value may be found from the formula

$$a_1 \begin{vmatrix} b_2 & c_2 \\ b_3 & c_3 \end{vmatrix} - a_2 \begin{vmatrix} b_1 & c_1 \\ b_3 & c_3 \end{vmatrix} + a_3 \begin{vmatrix} b_1 & c_1 \\ b_2 & c_2 \end{vmatrix} =$$

$$a_1b_2c_3 + a_2b_3c_1 + a_3b_1c_2 - a_1b_3c_2 - a_2b_1c_3 - a_3b_2c_1$$

Determinants of still higher order may be written, but they are of no interest to us in this article.

Properties of determinants useful in construction of nomographs are as follows:

• All of the rows may be rearranged as columns and all of the columns as rows without changing the value of the determinant provided that the row and column sequences are not changed.

$$\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} = \begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix}$$

• Interchanging adjacent rows or columns changes the sign of the determinant.

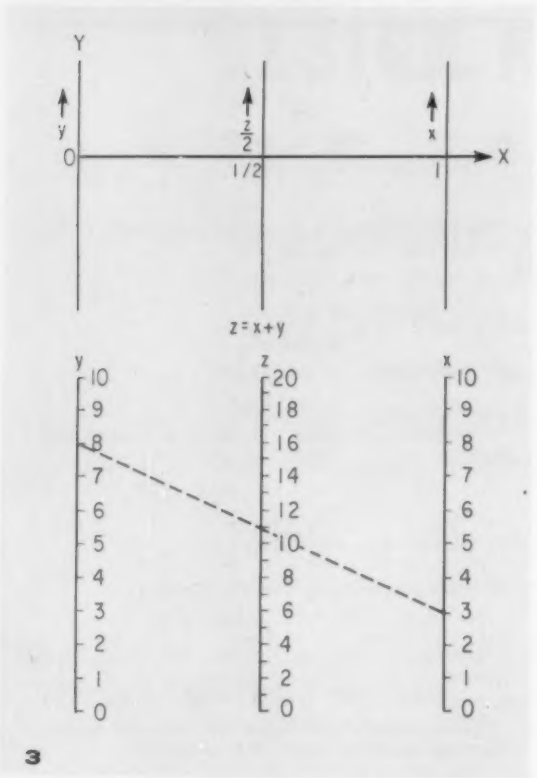
$$\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} = - \begin{vmatrix} a_1 & c_1 & b_1 \\ a_2 & c_2 & b_2 \\ a_3 & c_3 & b_3 \end{vmatrix} = \begin{vmatrix} c_1 & a_1 & b_1 \\ c_2 & a_2 & b_2 \\ c_3 & a_3 & b_3 \end{vmatrix}$$

• Multiplying the elements of any row or column by an arbitrary factor is equivalent to multiplying the entire determinant by the same factor.

$$\begin{vmatrix} 2a_1 & b_1 & c_1 \\ 2a_2 & b_2 & c_2 \\ 2a_3 & b_3 & c_3 \end{vmatrix} = 2 \begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}$$

• The value of the determinant is not changed by adding the element of any row (or column) to the elements of an adjacent row (or column) multiplied by an arbitrary factor.

$$\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix} = \begin{vmatrix} a_1 & b_1 & (c_1 + 2b_1) \\ a_2 & b_2 & (c_2 + 2b_2) \\ a_3 & b_3 & (c_3 + 2b_3) \end{vmatrix}$$



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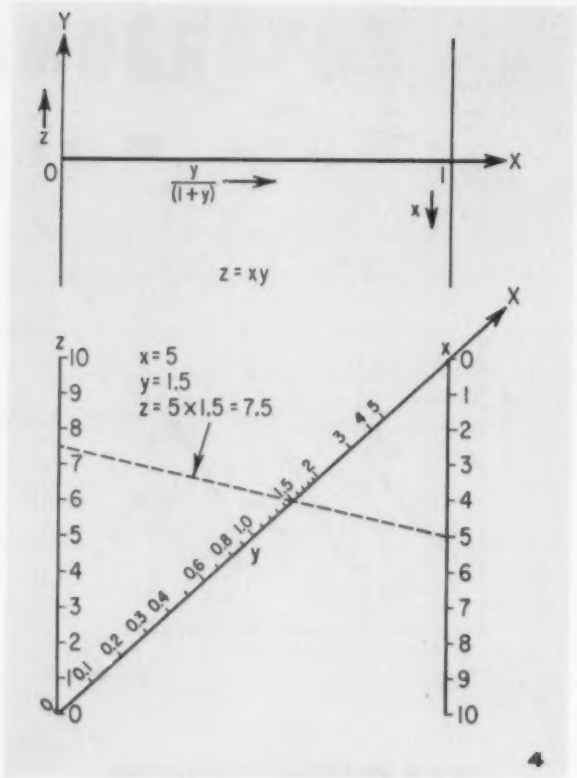


4

ments of column 3 and then dividing the elements of row 1 by two:

$$\begin{vmatrix} z & 1 & 1 \\ x & 1 & 0 \\ y & 0 & 1 \end{vmatrix} = \begin{vmatrix} z & 1 & 2 \\ x & 1 & 1 \\ y & 0 & 1 \end{vmatrix} = 2 \begin{vmatrix} \frac{z}{2} & \frac{1}{2} & 1 \\ x & 1 & 1 \\ y & 0 & 1 \end{vmatrix} \qquad (8)$$

In step (d), we will let the first column of the final determinant represent the displacement on the vertical axis so that the nomograph stems will run in the conventional vertical direction. From (8), we obtain the following relations:

$$Y = \frac{z}{2}, \quad X = \frac{1}{2}$$
$$Y = x, \quad X = 1$$
$$Y = y, \quad X = 0$$

Fig 3 shows the nomograph layout and then as scaled for ranges of x, y and z as follows:

$$0 \leqq x \leqq 10$$
$$0 \leqq y \leqq 10$$
$$0 \leqq z \leqq 20$$

Product of Two Variables

Let us next construct a nomograph of the general equation for the product of two variables,

$$z = xy \qquad (9)$$

In step (a), we set the function equal to zero:

$$z - xy = 0 \qquad (10)$$

In step (b), we express the function as a determinant. Care is taken to avoid having two variables in one row.

$$z - xy = \begin{vmatrix} z & 0 & 1 \\ -x & 1 & 0 \\ 0 & y & 1 \end{vmatrix}$$

In step (c), we may transform the determinant into the nomographic form by adding column 2 to column 3 and then dividing row 3 by $(1 + y)$:

$$\begin{vmatrix} z & 0 & 1 \\ -x & 1 & 0 \\ 0 & y & 1 \end{vmatrix} = \begin{vmatrix} z & 0 & 1 \\ -x & 1 & 1 \\ 0 & y & (1+y) \end{vmatrix}$$

$$= (1+y) \begin{vmatrix} z & 0 & 1 \\ -x & 1 & 1 \\ 0 & \frac{y}{(1+y)} & 1 \end{vmatrix} \qquad (11)$$

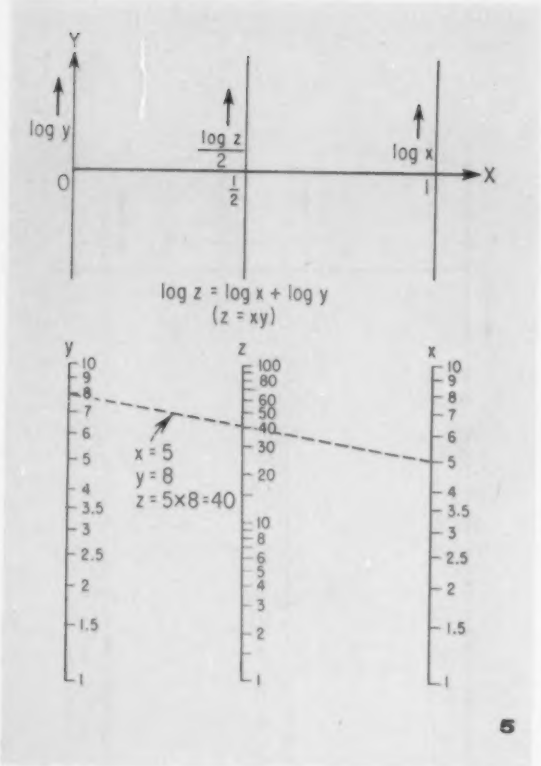
From (11), we obtain the following relations:

$$Y = z, \quad X = 0$$
$$Y = -x, \quad X = 1$$
$$Y = 0, \quad X = \frac{y}{(1+y)}$$

Fig 4 shows the nomograph layout and then as scaled for ranges of

$$0 \leqq x \leqq 10$$
$$0 \leqq y \leqq 5$$
$$0 \leqq z \leqq 10$$

We may tilt the X axis as shown in the scaled drawing in



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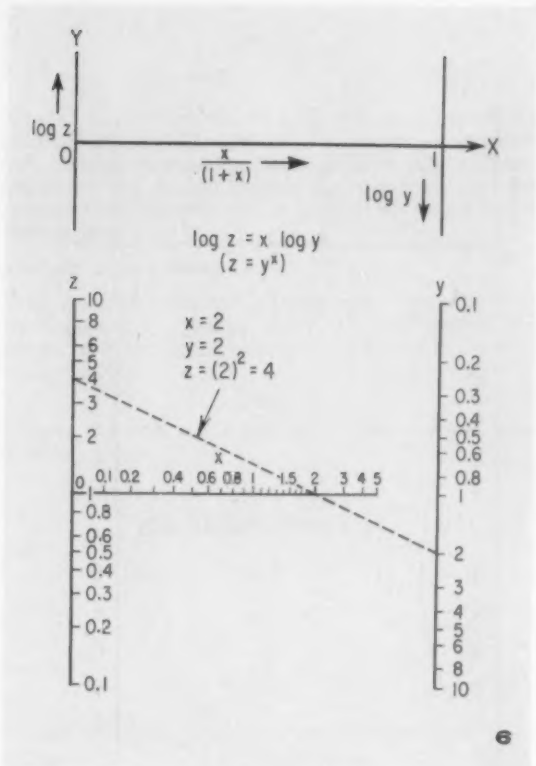


6

order to produce a more compact nomograph since the axes need not be perpendicular to satisfy the determinant.

Frequently, it is more desirable to use logarithmic scales in the nomograph of the product of two variables so that the ranges of the variables may be readily extended within a small space. Expressing Eq (9) in logarithmic form, we obtain

$$\log z = \log x + \log y \tag{12}$$

This equation has the same form as Eq (6), and we may obtain a nomograph of it using the procedure given for Eq (6). Fig 5 shows the nomograph layout and then as scaled for ranges of

$$1 \leqq x \leqq 10$$
$$1 \leqq y \leqq 10$$
$$1 \leqq z \leqq 100$$

Variable Raised to a Variable Exponent

Let us next construct a nomograph of the equation for a variable raised to a variable exponent,

$$z = y^x \tag{13}$$

To obtain a determinant which has functions of only one variable in each row, we must first express this equation in a logarithmic form:

$$\log z - x \log y = 0 \tag{14}$$

We next express Eq (14) as a determinant, taking care to avoid having functions of two variables in one row:

$$\log z - x \log y = \begin{vmatrix} \log z & 0 & 1 \\ -\log y & 1 & 0 \\ 0 & x & 1 \end{vmatrix}$$

We may transform the determinant into the nomographic form by adding column 2 to column 3 and then dividing row 3 by $(1 + x)$:

$$\begin{vmatrix} \log z & 0 & 1 \\ -\log y & 1 & 0 \\ 0 & x & 1 \end{vmatrix} = \begin{vmatrix} \log z & 0 & 1 \\ -\log y & 1 & 1 \\ 0 & x & (1+x) \end{vmatrix}$$

$$= (1+x) \begin{vmatrix} \log z & 0 & 1 \\ -\log y & 1 & 1 \\ 0 & \frac{x}{(1+x)} & 1 \end{vmatrix}$$

From the final determinant, we obtain the following relations:

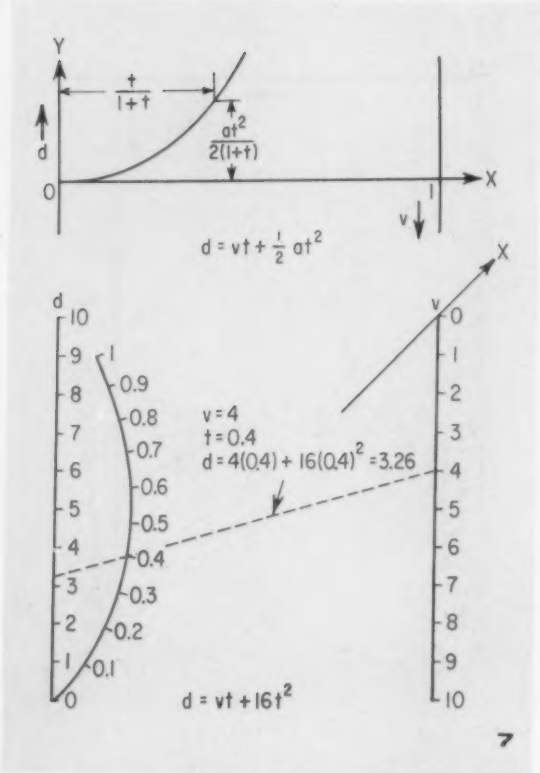
$$Y = \log z, \quad X = 0$$
$$Y = -\log y, \quad X = 0$$
$$Y = 0, \quad X = \frac{x}{(1+x)}$$

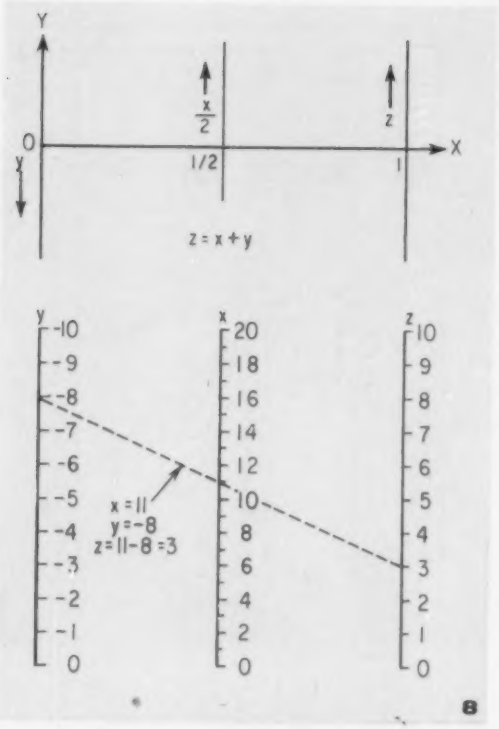
Fig 6 shows the nomograph layout and then as scaled for ranges of x, y and z as follows:

$$0 \leqq x \leqq 5$$
$$0.1 \leqq y \leqq 10$$
$$0.1 \leqq z \leqq 10$$

Curved Stems

The nomographs we have discussed so far have all been constructed entirely with straight-line stems, resulting from the fact that the nomographic determinant always contained only one entry of a function of a variable in each row. For certain





forms of equations, the nomographic determinant will be found to have two entries of functions of a variable in a single row, resulting in a curved stem for this variable. Let us now construct a nomograph for an equation of this type:

$$d = vt + \tfrac{1}{2}at^2 \qquad (15)$$

where d = distance traveled by a uniformly accelerated body,
v = velocity of the body at the start of the period of time being considered,
t = time during which the body is uniformly accelerated,
a = acceleration.

Assuming the acceleration a to be a constant, we first equate the function of three variables to zero:

$$d - vt - \tfrac{1}{2}at^2 = 0 \qquad (16)$$

We now express Eq (16) as a determinant, taking care to avoid having functions of two variables in one row:

$$d - vt - \tfrac{1}{2}at^2 = \begin{vmatrix} d & 0 & 1 \\ -v & 1 & 0 \\ \dfrac{at^2}{2} & t & 1 \end{vmatrix}$$

In the next step, we may transform the determinant into the nomographic form by adding column 2 to column 3 and then dividing row 3 by $(1 + t)$:

$$\begin{vmatrix} d & 0 & 1 \\ -v & 1 & 0 \\ \dfrac{at^2}{2} & t & 1 \end{vmatrix} = \begin{vmatrix} d & 0 & 1 \\ -v & 1 & 1 \\ \dfrac{at^2}{2} & t & (1+t) \end{vmatrix}$$

$$= (1+t)\begin{vmatrix} d & 0 & 1 \\ -v & 1 & 1 \\ \dfrac{at^2}{2(1+t)} & \dfrac{t}{(1+t)} & 1 \end{vmatrix}$$

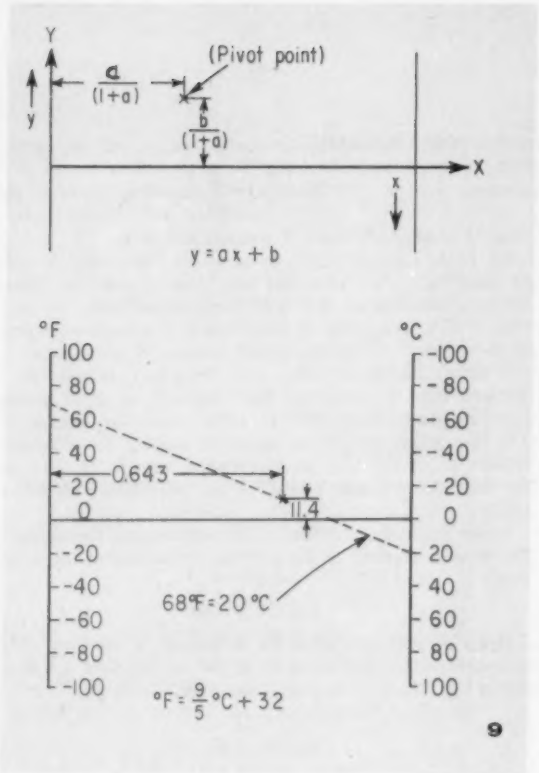
From the final determinant we obtain the following relations:

$$Y = d, \qquad X = 0$$
$$Y = -v, \qquad X = 1$$
$$Y = \frac{at^2}{2(1+t)}, \quad X = \frac{t}{(1+t)}$$

Fig 7 shows the nomograph layout and then as scaled for

$$a = 32$$
$$0 \leq d \leq 10$$
$$0 \leq v \leq 10$$
$$0 \leq t \leq 1$$

The X axis has been tilted so as to obtain a more compact chart. Then scale $t/(1 + t)$ along the slanted X axis. Scale $at^2/2(1 + t)$ on the d axis and project parallel to the X axis.



9

Scaling Factors and Stem Locations

The only rule which guides us in expressing the functions of three variables as a determinant so that it may be transformed into the nomographic form is that functions of two different variables must not appear in one row. Thus, it is possible for us to fill in the checkerwork of the determinant in many different ways and thereby obtain many different nomographs of an equation.

For example, Eq (7) may also be written in the form,

$$z - x - y = \begin{vmatrix} z & 1 & 0 \\ x & 1 & 1 \\ -y & 0 & 1 \end{vmatrix} = 2 \begin{vmatrix} z & 1 & 1 \\ \frac{x}{2} & \frac{1}{2} & 1 \\ -y & 0 & 1 \end{vmatrix} \qquad (17)$$

The final determinant gives the following relations:

$$Y = z, \quad X = 1$$
$$Y = \frac{x}{2}, \quad X = \frac{1}{2}$$
$$Y = -y, \quad X = 0$$

Fig 8 gives the nomograph layout and then as scaled for ranges of

$$0 \leq x \leq 20$$
$$-10 \leq y \leq 0$$
$$0 \leq z \leq 10$$

Note that we have been able to obtain different relative scaling factors and different relative locations for the stems of the nomograph by using different approaches in setting up the determinant (see Fig 3). In practical application we may take advantage of this feature in order to construct nomographs having optimum designs.

Equations of Two Variables

The determinant method of nomograph construction may also be applied to equations having only two variables. For example, let us consider the slope-intercept form of the equation of a straight line.

$$y = ax + b \qquad (18)$$

Following the steps required in the nomograph construction, we obtain

$$y - ax - b = \begin{vmatrix} y & 0 & 1 \\ -x & 1 & 0 \\ b & a & 1 \end{vmatrix}$$

$$= (1+a) \begin{vmatrix} y & 0 & 1 \\ -x & 1 & 1 \\ \frac{b}{(1+a)} & \frac{a}{(1+a)} & 1 \end{vmatrix}$$

The final determinant gives the following relations:

$$Y = y, \quad X = 0$$
$$Y = -x, \quad X = 1$$
$$Y = \frac{b}{(1+a)}, \quad X = \frac{a}{(1+a)}$$

Fig 9 gives the nomograph layout and then as scaled for the familiar Fahrenheit vs Centigrade temperature conversion. To save space in a practical application, this nomograph, or the nomograph of any equation involving only two variables, is usually reduced to a single line with different scales on either side since, for each value of one variable, there is only one corresponding value of the other variable.

Equations of More Than Three Variables

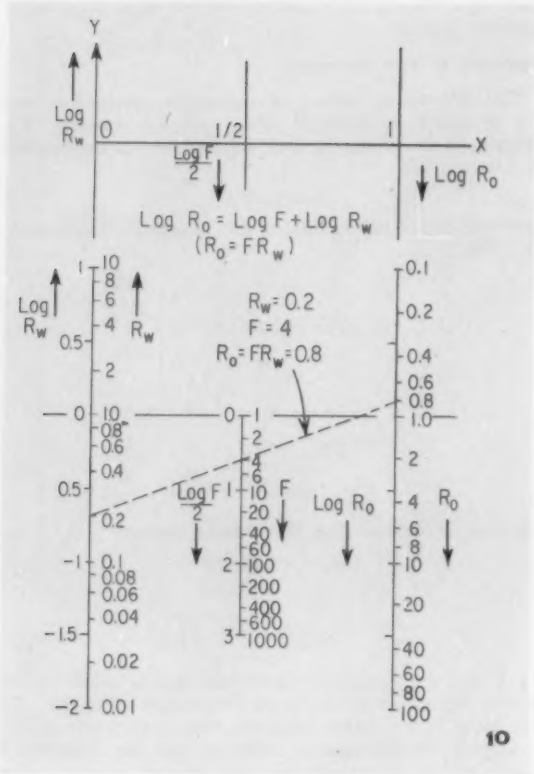
If the equation contains more than three variables it is necessary to construct its nomograph from more than one determinant. Actually, more than one nomograph is derived; but the separate nomographs are later combined to form a single group. There are many details involved in obtaining the optimum design of a multiple nomograph since combining the separate nomographs requires matching the locations and scaling factors of some of the stems.

A petroleum engineering equation used in the interpretation of electrical resistance measurements (logs) of bore holes provides us with an excellent example for studying some of the problems involved in multiple nomograph construction:

$$S_w^n = \left(\frac{FR_w}{R_t}\right)^{1/n} \qquad (19)$$

where S_w = percent water saturation of reservoir rock,
F = formation resistivity factor of reservoir rock,
R_w = resistivity of formation water,
R_t = true resistivity of reservoir rock,
n = saturation exponent of reservoir rock,

continued next page



All five are variables; S_w is the unknown. Three nomographs are necessary to complete the solution to this equation.

For step (a), we transform Eq (19) into a function of three variables by letting

$$r = \frac{FR_w}{R_t} \tag{20}$$

so that

$$S_w = (r)^{1/n} \tag{21}$$

Eq (20) must also be transformed into a function of three variables, and we will do this by letting

$$R_o = FR_w \tag{22}$$

so that

$$r = \frac{R_o}{R_t} \tag{23}$$

Eq (22) and (23) may be recognized as two additional parameters used in electrical log intepretation. In Eq (23) R_o = resistivity of reservoir rock fully saturated with formation water. In (23), r is the reciprocal of the expression more generally used in studies in this field,

$$I = \frac{1}{r} = \frac{R_t}{R_o} \tag{24}$$

where I = resistivity index of reservoir rock.

Eq (21), (22) and (23) must all be constructed in order to solve Eq (19). Note that two pairs of equations have a common variable so that the three nomographs, having a total of nine stems, may be combined into a single nomograph of seven stems. In a conventional manner of presentation, we will make this combination such that the unknown S_w is obtained from a continuous line consisting of three straight segments drawn from left to right across the nomograph. The line segments will be joined by making the dependent variable R_o of Eq (22) an independent variable of (23) and the dependent variable r of (23) an independent variable of (21).

Before proceeding further, we should consider the ranges of the variables required in the practical application of the nomograph:

$$\begin{aligned} 3 &\leqq F \leqq 1000 \\ 0.01 &\leqq R_w \leqq 10 \\ 0.1 &\leqq R_o \leqq 100 \\ 0.1 &\leqq R_t \leqq 10{,}000 \\ 0.01 &\leqq r \leqq 1 \\ 1 &\leqq n \leqq 3 \\ 0.01 &\leqq S_w \leqq 1 \end{aligned}$$

These ranges are large, so the most useful nomograph is likely to be with logarithmic scales.

Continuing with the nomograph construction, we first express Eq (22) in logarithmic form and equate its function to zero:

$$R_o = FR_w \tag{22}$$

$$\log R_o = \log F + \log R_w$$

$$\log R_o - \log F - \log R_w = 0$$

We next express the function as a determinant and transform the determinant into the nomographic form:

$$\log R_o - \log F - \log R_w = \begin{vmatrix} \log R_o & 1 & 1 \\ \log F & 1 & 0 \\ \log R_w & 0 & 1 \end{vmatrix}$$

$$= 2 \begin{vmatrix} \frac{\log R_o}{2} & \frac{1}{2} & 1 \\ \log F & 1 & 1 \\ \log R_w & 0 & 1 \end{vmatrix}$$

From the final determinant we obtain the following relations:

$$Y = \frac{\log R_o}{2}, \quad X = \tfrac{1}{2}$$

$$Y = \log F, \quad X = 1$$

$$Y = \log R_w, \quad X = 0$$

We note that the F scale will appear on the right side of the nomograph. It is desirable, however, that the R_o scale be placed on the right in order that it may be attached to the nomograph of equation (23). One procedure which we may use is to

transform the original determinant into a new form with the log R_e row containing a one in column 2 and a zero in column 3. A simpler procedure is to write a completely new determinant which satisfies these conditions:

$$\log R_e - \log F - \log R_w = \begin{vmatrix} \log F & 1 & 1 \\ -\log R_w & 0 & 1 \\ \log R_e & 1 & 0 \end{vmatrix}$$

$$= 2 \begin{vmatrix} \frac{\log F}{2} & \frac{1}{2} & 1 \\ -\log R_w & 0 & 1 \\ \log R_e & 1 & 1 \end{vmatrix}$$

The final determinant gives the following relations:

$$Y = \frac{\log F}{2}, \qquad X = \tfrac{1}{2}$$
$$Y = -\log R_w, \qquad X = 0$$
$$Y = \log R_e, \qquad X = 1$$

For purposes of illustration, let us assume that we would like the R_w scale on the left to be increasing in the conventional plus Y direction. We may obtain this condition by simply multiplying column 1 of the determinant by minus one:

$$2 \begin{vmatrix} \frac{\log F}{2} & \frac{1}{2} & 1 \\ -\log R_w & 0 & 1 \\ \log R_e & 1 & 1 \end{vmatrix} = -2 \begin{vmatrix} -\frac{\log F}{2} & \frac{1}{2} & 1 \\ \log R_w & 0 & 1 \\ -\log R_e & 1 & 1 \end{vmatrix}$$

We now obtain the following relations:

$$Y = -\frac{\log F}{2}, \qquad X = \tfrac{1}{2}$$
$$Y = \log R_w, \qquad X = 0$$
$$Y = -\log R_e, \qquad X = 1$$

Fig 10 shows the nomograph layout and then as scaled.

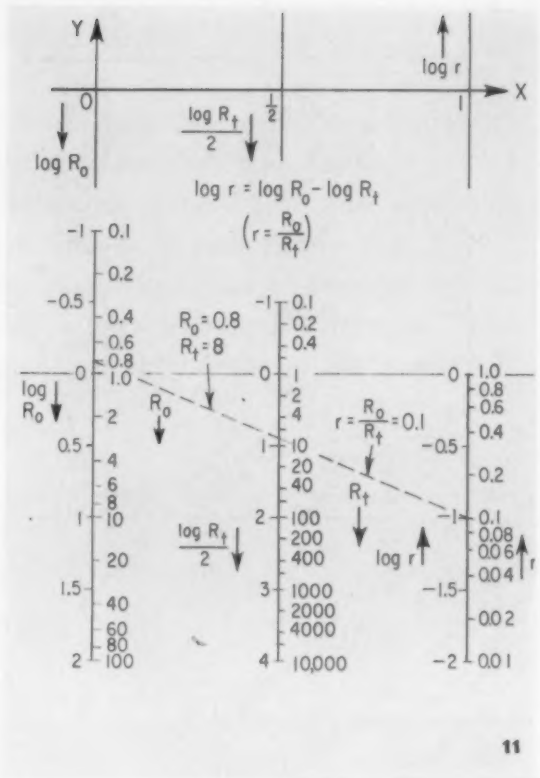
A nomograph for solution to Eq (23) may be constructed in a manner similar to that used on Eq (22).

We must keep in mind, however, that the R_e scale should be on the left side of the nomograph and the r scale should be on the right. Furthermore, the R_e scale should be logarithmic and increasing in the minus Y direction as shown in Fig 10.

Our procedure is first to express Eq (23) in a logarithmic form and equate the function to zero:

$$r = \frac{R_e}{R_t} \qquad (23)$$
$$\log r = \log R_e - \log R_t$$
$$\log r - \log R_e + \log R_t = 0$$

We may obtain a determinant which will give the proper placement and scaling of the nomograph stems by first inserting $-\log R_e$ in a row containing a zero in column 2 and a one in column 3 and $\log r$ in a row containing a one in column 2 and a zero in column 3 and then completing the other parts



11

of the determinant as required by the function:

$$\log r - \log R_e + \log R_t = -\begin{vmatrix} \log r & 1 & 0 \\ -\log R_e & 0 & 1 \\ -\log R_t & 1 & 1 \end{vmatrix}$$

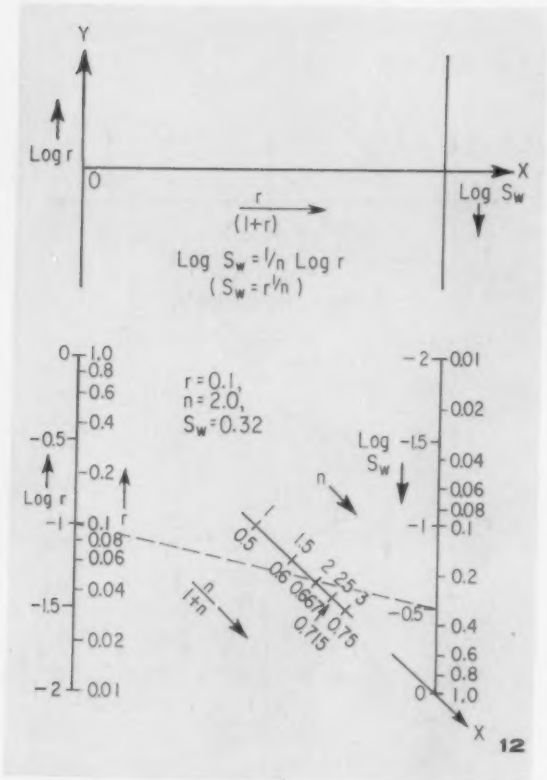
$$= -2 \begin{vmatrix} \log r & 1 & 1 \\ -\log R_e & 0 & 1 \\ -\frac{\log R_t}{2} & \frac{1}{2} & 1 \end{vmatrix}$$

The final determinant gives the following relations:

$$Y = \log r, \qquad X = 1$$
$$Y = -\log R_e, \qquad X = 0$$
$$Y = -\frac{\log R_t}{2}, \qquad X = \tfrac{1}{2}$$

Fig 11 shows the nomograph layout and then as scaled.

We may obtain a nomograph for solution to Eq (21) by



first expresing the equation in the logarithmic form and equating its function to zero:

$$S_w = (r)^{1/n} \tag{21}$$

$$n \log S_w = \log r$$

$$n \log S_w - \log r = 0$$

We then obtain a determinant which will give the proper place ment and scaling of the nomograph stems (log r on the left and log S_w on the right, with the log r scale increasing in the plus Y direction as shown in Fig 11):

$$n \log S_w - \log r = \begin{vmatrix} -\log S_w & 1 & 0 \\ \log r & 0 & 1 \\ 0 & n & 1 \end{vmatrix} = (1+n) \begin{vmatrix} -\log S_w & 1 & 1 \\ \log r & 0 & 1 \\ 0 & \frac{n}{(1+n)} & 1 \end{vmatrix}$$

The final determinant shows the following relations:

$$Y = -\log S_w, \quad X = 1$$

$$Y = \log r, \quad X = 0$$

$$Y = 0, \quad X = \frac{n}{(1+n)}$$

The nomograph layout is shown in Fig 12 and then as scaled. Since we are not interested in values of r and S_w which are greater than one, we may tilt the X axis (as shown in the scaled drawing) so as to produce a more compact chart.

Fig 13 shows the completed nomograph for solution to Eq (19). The stem for r in Fig 11 and 12 has been rescaled in terms of I as given in Eq (24) since I is of more general interest in electrical log interpretation.

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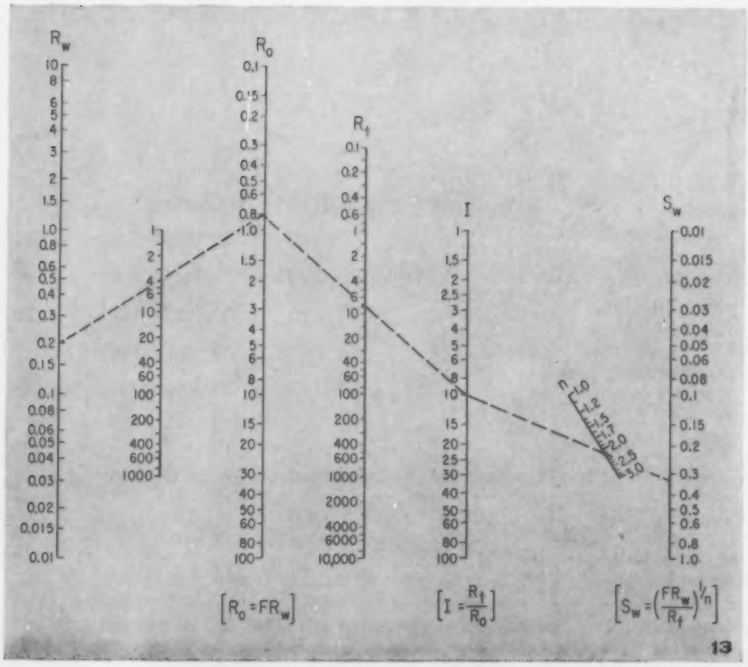

FOR FURTHER REFERENCE

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3. F. T. Mavis, *The Construction of Nomographic Charts*, International Textbook Co, 1939.
4. Raymond D. Douglass and Douglas P. Adams, *Elements of Nomography*, McGraw-Hill Book Co, 1947.
5. C. Albert Kulmann, *Nomographic Charts*, McGraw-Hill Book Co, 1951.

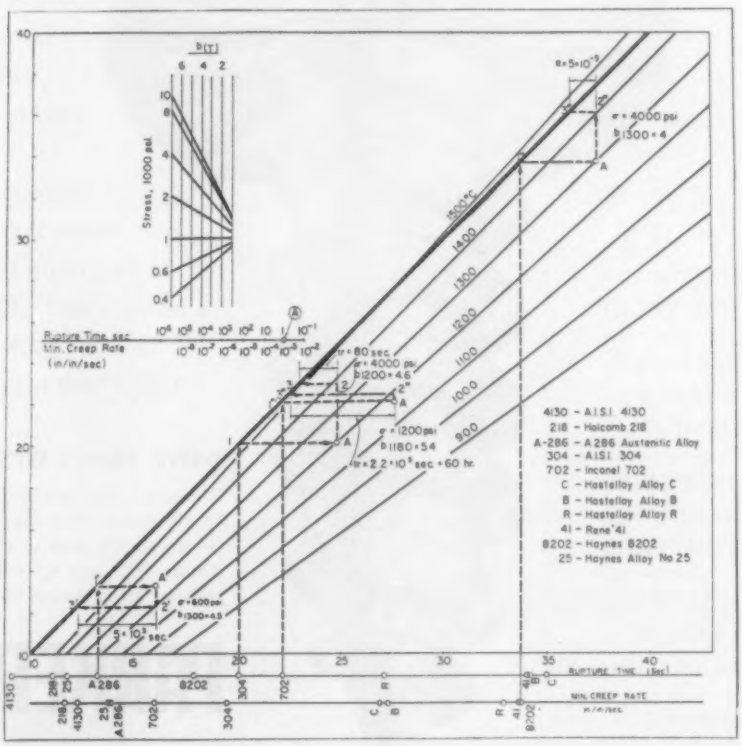
chart shows
Alloys' Hi-temp Creep-rupture Behavior

Equations relating time to rupture and minimum creep rate with temperature and stress have been developed by M. Korchynsky, a research metallurgist with Union Carbide Metals Co. The equations, shown graphed below, are applicable to any one of 11 common hi-temp alloys. You enter with temperature and stress level and read off rupture time or creep rate. The equations have proved so accurate that parameters established by only a few creep-rupture tests of a few minutes' duration have successfully predicted rupture times (at lower stresses) of several hundred hours duration.

From the selected alloy draw a line vertically up to the diagonal (point 1) and then horizontally to the desired temperature line. From this intersection, marked A, the value of stress (psi) is measured vertically (from A to 2). Stress greater than $\sigma/1000 = 1$ is plotted above the point A, whereas stress smaller than $\sigma/1000 = 1$ is plotted below the point A.

The distance representing stress (A −2) depends on the appropriate value of the temperature dependent parameter $b_{(T)}$, and is taken from the graph in the upper left corner of the chart. For annealed type 304 stainless steel, $b_{(1400)} = 5.94$; $b_{(1400)} = 3.45$. If the accurate value of $b_{(T)}$ is not known, the value of 4 can be used as its first approximation. From the point 2, a horizontal is drawn again to intersect the diagonal at 3.

The distance between 2 and 3 represents time to rupture, or minimum creep rate for the selected temperature and stress, and is measured on the horizontal scale, starting from the point marked A. It follows that for stress equal unity ($\sigma/1000 = 1$), the time of rupture or minimum creep rate is represented directly by the horizontal distance 1—A. Similarly, the distance measured vertically from the point A to the intersection with the diagonal represents the stress which will produce rupture time of 1 second or minimum creep rate equal to 10^{-6} in./in./sec. Several examples of the described procedure for graphical determination of rupture time or minimum creep rate are shown. ■



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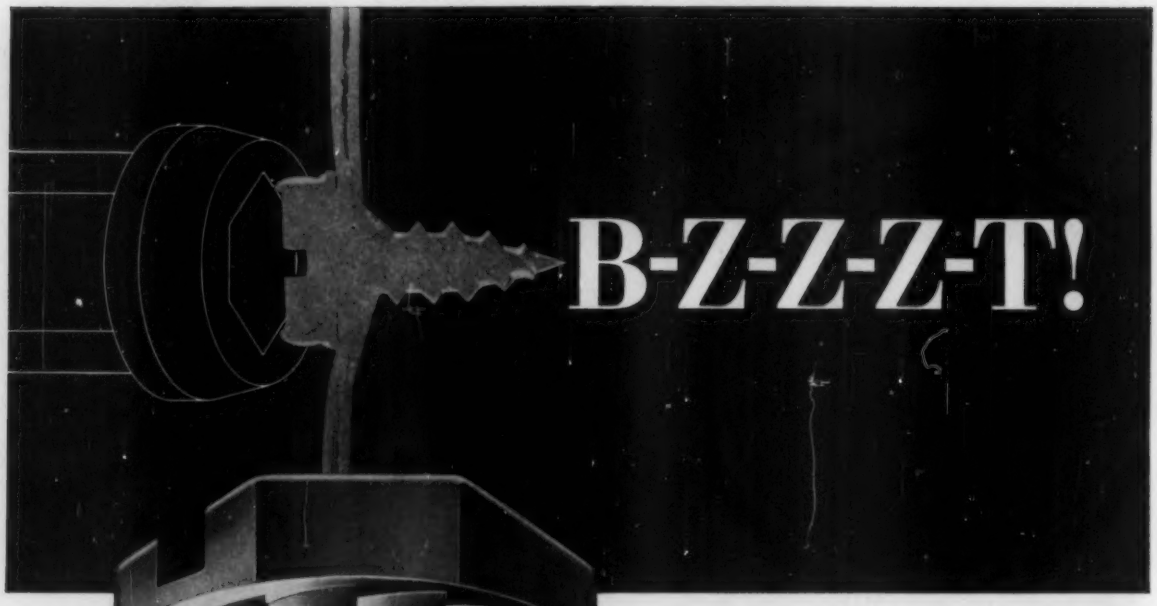

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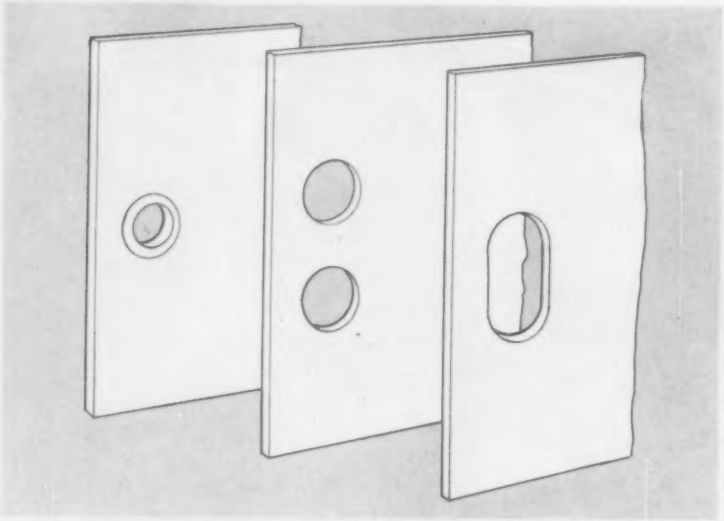
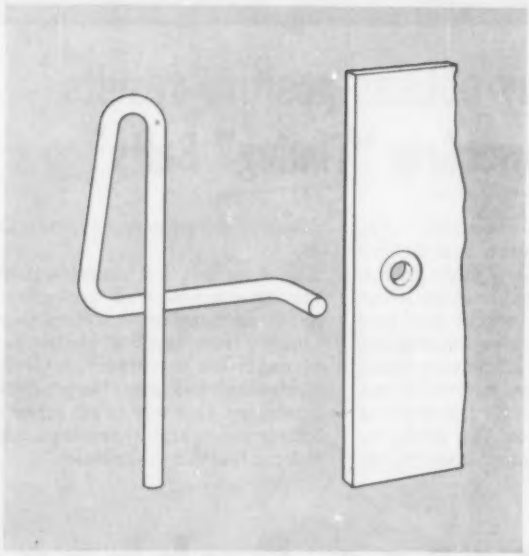
HANDLES for PRINTED CIRCUITS

Seven simple designs for making maintenance easier. More in a later issue.

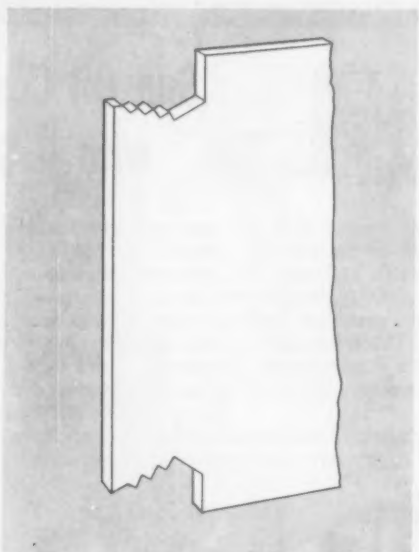
I N SCHUSTER, *product design engineer, Raytheon Co*



1
PUNCHED OR DRILLED HOLES are adequate if space between boards is sufficient for finger insertion. Grommets may be required in some materials.

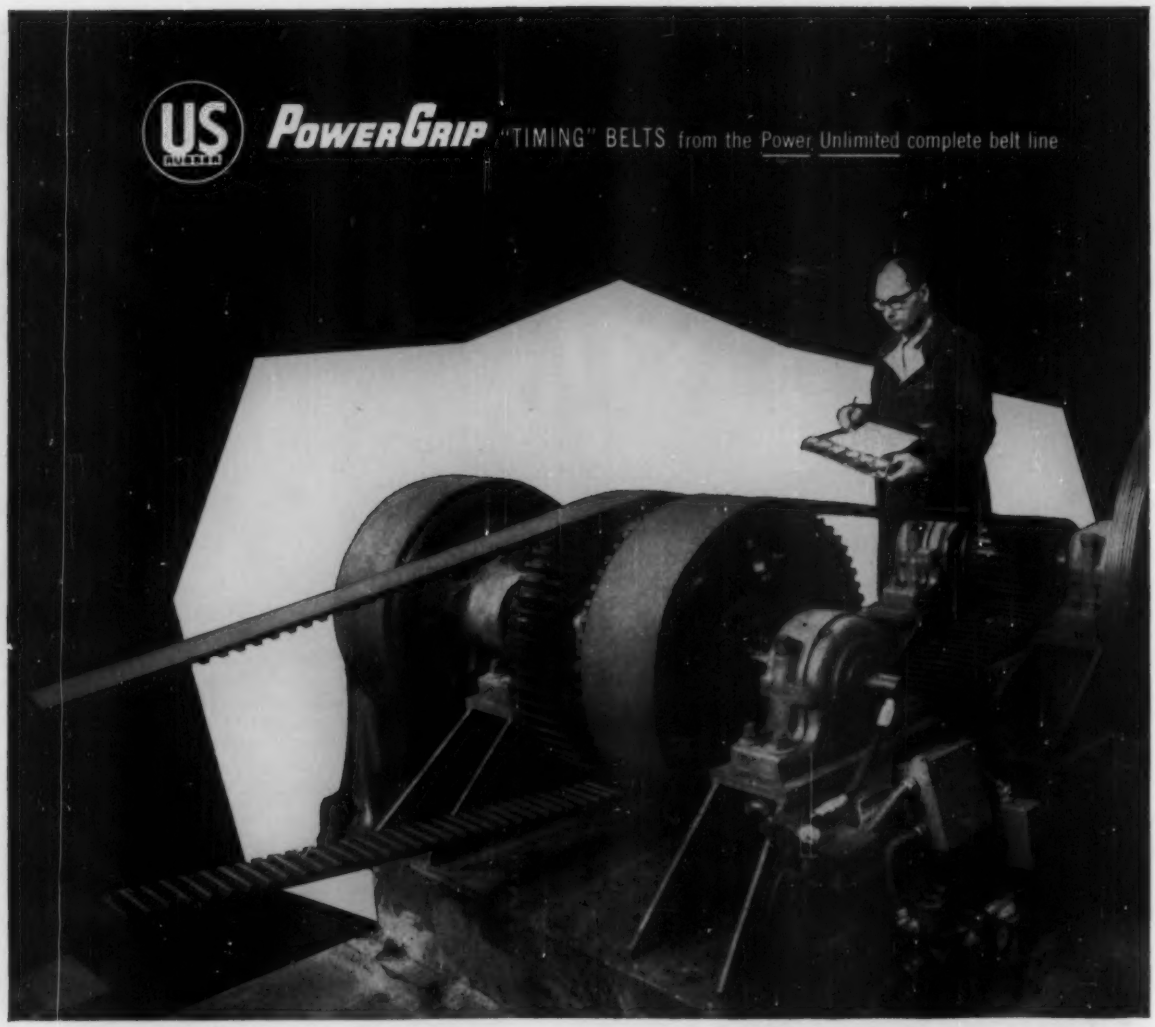


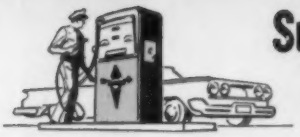
2
SMALL EYELET and removable extractor works well when space and weight are at a premium.



3
SERRATED FINGER GRIPS are often best when spacing of boards is extremely close.

continued on page 79





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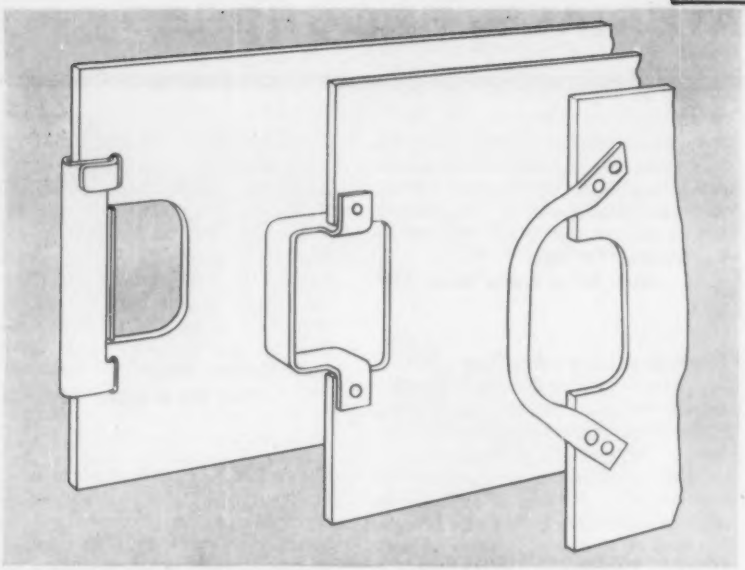
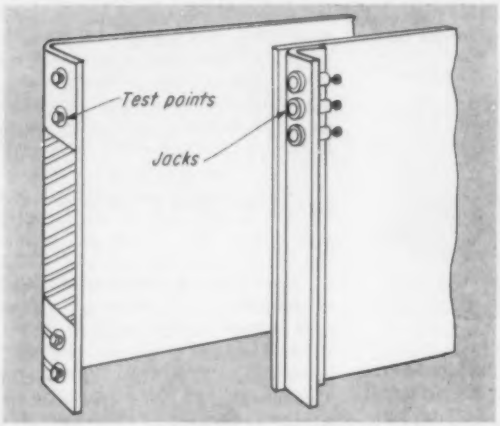
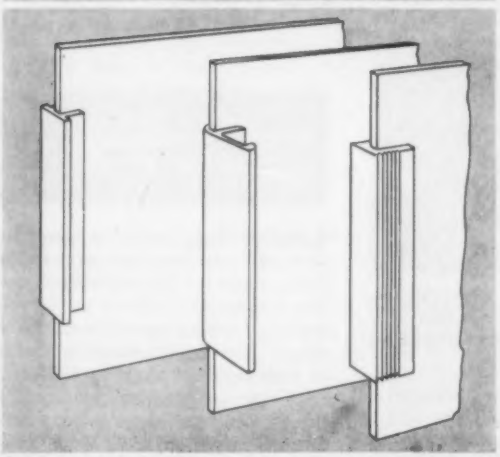


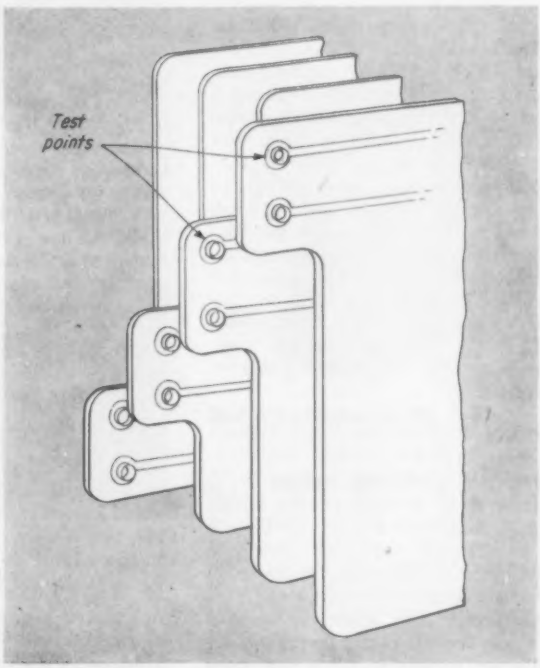
4
INDIVIDUAL HANDLES, tabbed or riveted in place, may be called for on large boards.



5
FORMED BOARDS do double duty when test points and jacks are incorporated into handles.

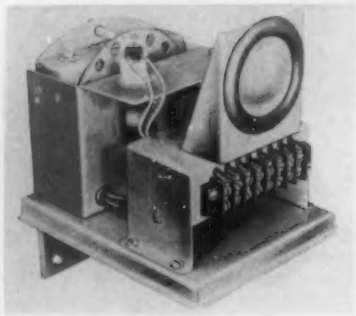


6
EXTRUSIONS staked, crimped or pinned in place form attractive withdrawal aids.



7
STAGGERED POSITIONS of removal tabs give easy access to test points on closely spaced panels.

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Photoelectric temperature control . . .

monitors temperature of moving parts or continuous strip, counts heated workpieces, controls automatic quenching and induction or resistance heaters. Functions by measuring infrared radiation. Pickup, with infrared sensitive photocell, is aimed at heated surface. An amplifier, temperature-selection dial and output is housed in separate control unit. When temperature of heated workpiece exceeds that of preset level, relay operates. One model is for control of temperatures 500 F or greater from area of 0.125 sq in. at distance of 1 ft. Ambient operating temperature range for control and pickup is 0 to 100 F. Second model is for control of temperatures of 1000 F or greater from area of 0.42 sq in. at distance of 1 ft. Repetitive accuracies of units are reported to be 1 and 10%, respectively, at lower end of temperature operating range. Both require min signal of 1/60th sec to operate relay; offer max operating rate of 600 per min. Power supply is 105-125 v, 60 cps. Various models range in price from $120 to $535. Delivery, about 3 wk. **Clark Controller Co, 1146 E 152nd St, Cleveland 10.**

Circle 300 on Reader Service Card

Dynamic pressure meter . . .

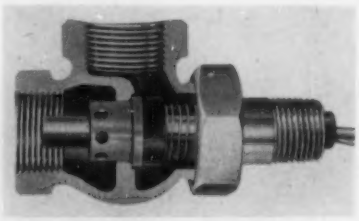
consists of up to four pressure sensors and electronic readout unit. Can be used to measure and readout individual pressures, pressure differentials, or any arithmetic combination of up to four pressures. Suitable signal is provided to output recorder. Separate plug-in units adapt any strain-gage pressure sensor to the instrument. Range switch is used to select ranges of 0-300, 0-1000 and 0-3000 psi. Instrument is available as rack-mounted device or as portable unit equipped with top-mounted handle. Unit is $975, less transducers (price of which varies according to specifications). Delivery, 6 wk. **American Measurement & Control Inc, Sub of CompuDyne Corp, 240 Calvary St, Waltham 54, Mass.**

Circle 301 on Reader Service Card

High-pressure coupling . . .

applicable to high-pressure gas or fluid systems is for service at 3000 to 4000 psi; with proof pressures of 6000 psi; burst pressures of 250% of rated pressures for 2 min. minimum. Push-pull coupling requires only one motion in direction of fluid flow to connect or disconnect. Available in stainless steel or aluminum in range of sizes. **Hydraulic Components Div, Deutsch Co, 7000 Avalon Blvd, Los Angeles 3.**

Circle 302 on Reader Service Card



Low-cost flow switch . . .

detects variation in flow rate of fluids or gases. Can operate remotely located warning light or other indicator, visual or audio. Automatic interlocks or pump motors can be actuated through suitable relays. Displacement of magnet-equipped shuttle by fluid or gas actuates hermetically sealed switch contacts within bronze stem. Bypass holes in shuttle skirt permit max flow with min pressure drop. Can be calibrated for actuation in any position. Replaces any standard elbow fitting and is available in port sizes from ¼ through 2 in. NPT. All components are said to be corrosion-resistant. Priced from $18.50 to $62, list. Delivery, 2 wk. **Gems Co Inc, Sheppard Lane, Farmington, Conn.**

Circle 303 on Reader Service Card

Single-crystal silicon . . .

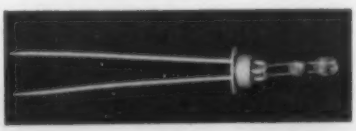
is reported to offer resistivity and lifetime profiles that indicate uniform characteristics over entire length of each crystal and from crystal to crystal. Uniformity is expected to result in increased quality semiconductor devices. Available in diameters to 26 mm (approximately 1 in.) and lengths to 250 mm (13¾ in.) undoped P-type single crystals are said to have less than 0.15 parts per billion of boron; greater than 1000 ohm cm; minority carrier lifetime, greater than 400 microsec. Price is $2.96 per gm. Production quantities are now available. **Dow Corning Corp, Midland, Mich.**

Circle 304 on Reader Service Card

Drive for X-Y axis control . . .

of point-to-point or continuous table movement can be programed and automatically impulsed to follow unlimited number of input signals to change speed or mode of operation. Speed changes, acceleration, deceleration, precision slowdown, precision shaft-rotation stop, dynamic braking and reversing can be sequenced. Commands can be given manually, mechanically, electrically or electronically. Available with ratings from 1/40 to 3 hp; priced from about $630 to $4200 per pair of nongeared drives. Delivery on fhp units, 10 wk; for integral units, 16-20 wk. Z-axis and rotational axis companion drives are also available. Control system components for manual or automatic line following, and grid position control are also available with line deviation accuracies from ±0.015 to ±0.001 in. **ECI Mfg Div, Electronic Controls Inc, 85 Magee Ave, Stamford, Conn.**

Circle 305 on Reader Service Card

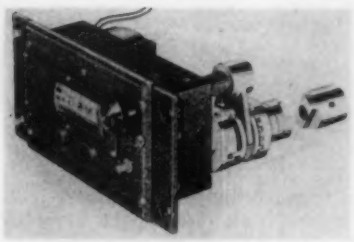


Resistor responds to gas . . .

or vapor whose molecules exhibit electric dipole moment. Has hermetically sealed glass-to-metal base for use in flow lines, pressure chambers and other sealed containers. Resistance changes in presence of polar molecules according to their concentration and magnitude of dipole moment. Resistance changes over smooth S curve and in air at 77 F ranges from 1000 megohm at 25% RH to 1-2 megohm at 98% RH. Characteristics are reported to include rapid response times,

insensitivity to temperature changes from 32 to 212 F, ability to recover from immersion in water without affecting operating parameters. Priced at $10 each. **Conrad-Carson Inc, 3110 Goddard Way, San Diego 1, Calif.**

Circle 306 on Reader Service Card



Illuminated digital indicator . . .

for high-speed position indication on machinery in poorly lit areas is panel-mounted. Magnifying lens enlarges figures to ½ in. or more. Lighting is provided by two 24-v ac bulbs, replaceable from front of panel. Electrical connections are made directly to 115-v, 60 cps ac, through terminal strip on back of counter and transformer for reduction to 24 v ac. Unit achieves counting rates up to 15,000 counts per min. with standard 10:1 ratio. Measures and reads to 0.001 or 0.0001 in. Counter is disengaged from driving shaft by clutch for adjustment and recalibration. Counter wheels are set with key or crank at face of counter. **Durant Mfg Co., 19-PS N Buffum St, Milwaukee 1.**

Circle 307 on Reader Service Card

4-figure electric counters . . .

are said to operate at speeds to 600 counts per min. Standard models are for 115-v ac operation. Available for base, top or panel mounting with panel plate. Based upon escapement drive mechanism. Driving parts are nylon with hardened stainless steel driveshaft. One-piece, die-cast aluminum frame with tight cover plate is tongued to frame to minimize entry of dust and foreign matter. Priced at $14 each. **Durant Mfg. Co, PS N Buffum St, Milwaukee 1.**

Circle 308 on Reader Service Card

Multipole, 400-cps power relay

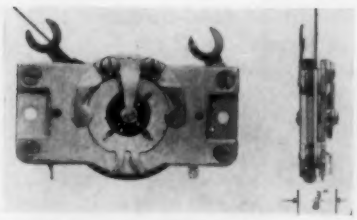
has self-wiping contacts that will continuously handle 10 amp loads at 28 v dc or 115 v ac. Available up to 3PDT, with octal plug and clear polystyrene high-heat cover. Dimensions are 1⅛ sq x 2$\frac{7}{16}$ in. high. High-speed relay is reported to handle most power applications. Prices range in quantities of 1 to 10 from $8.95 for SPDT to $11.45 for 3PDT. Delivery, about 6 wk. **Kurman Electric Co, 191 Newel St, Brooklyn 22, NY.**

Circle 309 on Reader Service Card

Spray-on Teflon lubricant . . .

for use on sliding surfaces or moving parts is odorless, colorless, tasteless, nonstaining white powder. Said to have low coefficient of friction, 0.016 to 0.024 against polished steel surface. Operating temperature range is from —450 to 400 F. Can be used on most surfaces over broad operating conditions. Powder can also be added to liquid and grease-type lubricants to increase lubricity characteristics. Furnished in 4 oz bottles and bulk packages for commercial and industrial applications. Free samples are offered. **Polydoris Products Corp, 5306 W Lawrence Ave, Chicago 30.**

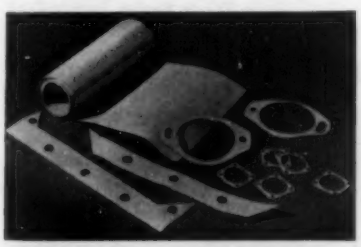
Circle 310 on Reader Service Card



Printed circuit meter movement

is incorporated in slim surface-mounting panel meters available in most standard ranges with reported accuracy of 1½%. Pointer is made of resilient nylon bristle said to be capable of withstanding effects of electrical overloads and turns of open printed-circuit coil are reported to dissipate more heat than conventional coils. These factors are said to combine to provide net overload tolerance of 10,000% with no adverse effect on accuracy of calibration of movement. Offered in full scale standard ranges of 1 ma through 1 amp dc, 10 through 500 v dc and 10 through 500 v ac. List prices range from $12.50 to $19. **Interlab Inc, 116 Kraft Ave, Bronxville, NY.**

Circle 311 on Reader Service Card



Conductive gasketing . . .

made of silicone rubber and metal material is said to conform to irregular surfaces. 30 or 24 mesh aluminum wire cloth is impregnated with 50-durometer silicone rubber to thickness of 0.016 and 0.020 in. Construction provides material said to withstand temperatures from —65 to 500 F. Recommended for use where conductive material is needed between two metal surfaces, to allow flow of electrical current while restricting or filtering any induced radio frequency. Available from stock in 8-in. widths at $8.55 per yd for quantities under 25 yd. **Connecticut Hard Rubber Co, 407 East St, New Haven, Conn.**

Circle 312 on Reader Service Card

15-amp silicon power rectifiers

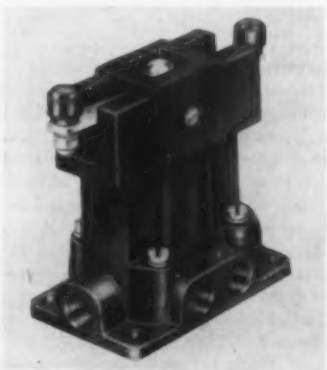
are diffused-junction devices reported to be priced at about 50% of the cost of comparable units now on the market. Available in 50, 100, 200, 300 and 400 v ratings. Prices range from $1.95 for the 50-v units to $3.50 for the 400-v devices in 100-up quantities. Rectifiers are housed in all-welded, hermetically sealed, $\frac{11}{16}$ in. hex stud-mounted package for heat sink or direct chassis mounting. Rated for temperatures up to 347 F. **Motorola Semiconductor Products Inc, 5005 E McDowell Rd, Phoenix, Ariz.**

Circle 313 on Reader Service Card

Flat nylon washer . . .

can be used as spacer or as an insulator and with any screw, bolt, pin, nail or rivet. Washer is said to have tensile strength of 15,000 psi. Available from stock in sizes up to ½ in. OD to fit screws from No. 3 through ⅜ in. dia. **Nyltite Corp of America, 280 Badger Ave, Newark 8, NJ.**

Circle 314 on Reader Service Card



Poppet-type directional valve

is compact unit for 250 psi max air or hydraulic service and temperature range of —40 to 160 F. Valve can be removed for maintenance without disturbing pipe connection. Group mountings can also be made, without pipe bracket, to common manifold. Three- and four-way operation models are available. By rearranging internal parts, operation can be changed. Button, lever and cam operators (manual and mechanical) can be reset, overridden or safety interlocked by dual air piloting. All materials used are noncorrosive. Of-

continued on page 82

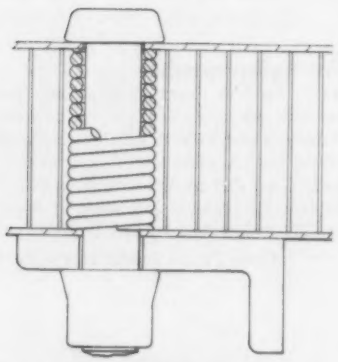
fered in ⅛ or ¼ in. tapped pipe brackets. Prices start at $18. Westinghouse Air Brake Co, Industrial Products Div, Wilmerding, Penna.

Circle 315 on Reader Service Card

Push-fit test jack . . .

for use with 0.80-in.-dia probes in electronic circuits is mounted by pressing into predrilled or punched hole. Contacts are beryllium copper, electro-tin plated to meet requirements of standard electronic circuit. Temperature range is −85 to 212 F. Insulators are molded nylon and are available from stock in blue, red and black. Prices range from 4½¢ each in quantities of 50,000 or more to 12¢ each for 10 to 99 units. Augat Bros Inc, 33 Perry Ave, Attleboro, Mass.

Circle 316 on Reader Service Card



Universal-type spiral spacer . . .

is for use when joining parts or materials and honeycomb panels to other hollow or core-type structures with fasteners. Available in any desired length for use with 5/32, ¼, 5/16 and ⅜ in. dia rivets, bolts or similar fastener. Spiral design and installation method permit use of same hole diameter as fastener. Said to provide optimum columnar support for panel face sheets and max joint strength, without marring or deflection of sheets. Huck Mfg Co, 2480 Bellevue Ave, Detroit 7.

Circle 317 on Reader Service Card

Magnetic reed switch . . .

is said to handle larger loads with more constant contact resistance throughout its life than previous models. Silver-plated contacts operate in 20 lb of pure hydrogen pressure. Measures 2½ in. long, with one rod end solid and the other end a hollow tube somewhat larger in dia. Glass OD is 0.200 ± .015 in. Contact rating is 50 v-amp max resistive up to 3 amp; up to 250 v. Actuating time is 1 millisec average. Hamlin Inc, Lake and Grove Sts, Lake Mills, Wis.

Circle 318 on Reader Service Card

Polyethylene molding resin . . .

is reported to offer high stress-crack resistance, withstanding more than 3000 hr of severe standard stress crack testing. Resin is produced by polymorphous technique, involving action of resin when formed to produce controlled molecular pattern and balance between crystalline and noncrystalline elements of material. The 0.919 density material with melt index of 1.4 is said to resemble materials of higher melt indices in processing, thereby allowing faster mold filling and reducing cooling time. Higher melt version of resin is also available. Spencer Chemical Co, Dwight Bldg, Kansas City 5, Mo.

Circle 319 on Reader Service Card

Miniature feed-through terminal . . .

secures directly to panel assemblies by means of integrally molded threaded body. Flats, which are also part of integral mold, facilitate insertion of threads into assembly with either automatic or manual coupling drive. Threads are ¼ in.-24 NS-2A. Tin-plated brass rod of terminal conforms to QQ-B-626 and HP4-14 specifications. Available with melamine or diallyl phthalate body in accordance with military specifications. Offered in full range of sizes and materials with male or female threaded and rivet-type mountings in molded or metal base. Whitso Inc, PE-1 Byron St, Schiller Park, Ill.

Circle 320 on Reader Service Card

High-voltage components . . .

can be molded of polyester fiber glass premix to specifications. Said to be low-cost low-moisture, absorbing, flame-retardant components, which can be used in corrosive atmosphere. Available in selection of colors. Also can be used as bus-bar supports, cable supports, breaker housing units and other high-voltage industrial needs. Firmaline Products of Crompton & Knowles, Midland Park, NJ.

Circle 321 on Reader Service Card

Differential-gage protector . . .

is for use in hydraulic, pneumatic or fuel systems having max operating pressure of 10,000 psi. Units will shut off at any predetermined differential pressures from 30 to 2000 psi and are available from stock in ¼ in. tube and ¼ in. pipe connections in aluminum and stainless. Fisher Controls Inc, 1754 22nd St, Santa Monica, Calif.

Circle 322 on Reader Service Card

Feed-through terminals . . .

include unit with double-turrets at each end and unit with double turrets at one end and single turret at the other. Heights, when mounted, are 0.241 in. on one end and 0.134 in. on the other end; 0.241 in. on double-turreted terminal and 0.032 in. on single-turreted terminal, respectively. Both terminals have shank dia of 0.125 in. Processed from brass per QQ-B-626A, Comp 22, ½ hard with 0.0003 in. silver plate plus water dip lacquer. Cambridge Thermionic Corp, 445 Concord Ave, Cambridge 38, Mass.

Circle 323 on Reader Service Card

Compact battery holder . . .

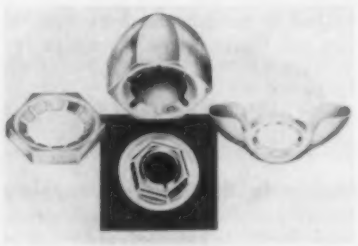
for portable electronic equipment is made of cadmium-plated steel or beryllium copper. Holder has silver-plated contacts pressed into nylon insulators. With both contacts insulated, battery is insulated from holder and chassis. Weighs about 0.018 lb. Prices for stock battery holder range from 45¢ up. Augat Bros Inc, 33 Perry Ave, Attleboro, Mass.

Circle 324 on Reader Service Card

Totally enclosed dc motors . . .

and generators are for both constant speed drives and drives involving fast, wide speed changes and reversals, automatic control or close regulation. Includes totally enclosed fan-cooled and nonventilated machines in both industrial and explosion-proof construction. Motors are rated from ½ to 60 hp at 300 to 3500 rpm; generators are rated from ¾ to 40 kw at 850 to 3450 rpm. Utilize high-temperature silicone insulation system for machines rated and built for continuous operation with temperature rise of 167 F. Blowers and heat exchanger are mounted at shaft end. Westinghouse Electric Corp, PO Box 2099, Pittsburgh 30.

Circle 325 on Reader Service Card



Stamped fasteners . . .

are currently being manufactured in four lines. Products include one-piece washer nuts, acorn nuts, regular nuts and wing nuts. Available in heat-treated spring steel in all popular sizes and finishes. Crest Products Inc, PO Box 64, Union, NJ.

Circle 326 on Reader Service Card

continued on page 86

Logan's 44th year...

...of uninterrupted service to industry

valves

cylinders

airline filter-lubricators

special pneumatic and hydraulic machines

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- ☐ 100-6 Ultramation Cylinders
- ☐ 300-2 Presses
- ☐ Facts of Life
- ☐ 200-1 Hyd. Power Units
- ☐ 200-2 Rotocast Hyd. Cyls.
- ☐ 200-3 750 Series Hyd. Cyls.
- ☐ 200-4 and 200-7 Hyd. Valves
- ☐ 200-6 Super-Matic Cyls.
- ☐ 300-1 Chucks
- ☐ ABC Booklet
- ☐ Circuit Rider

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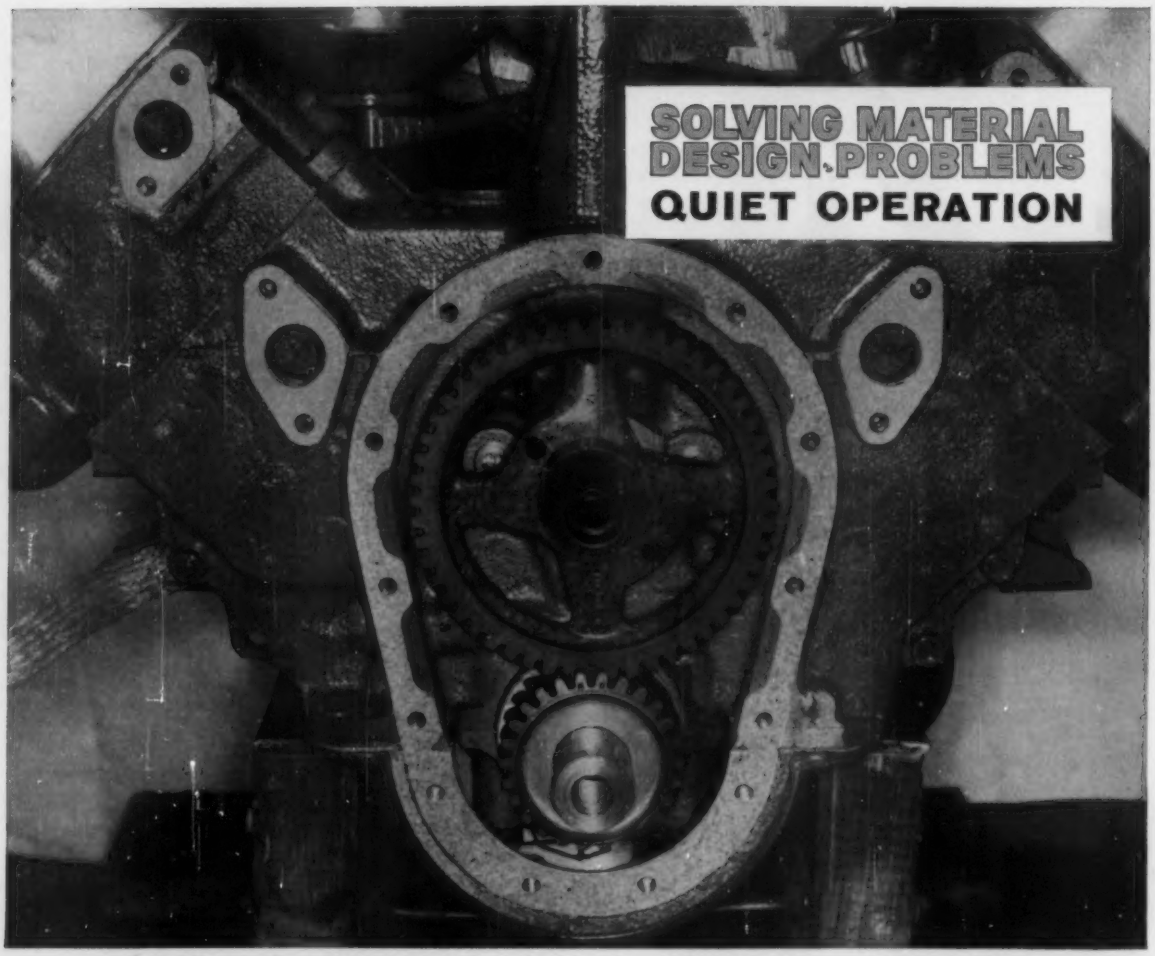
SPECIFY LOGAN EQUIPMENT

CIRCLE 83 ON READER SERVICE CARD



Timing gears made of CDF Celoron will not pick up and amplify sound due to Celoron's naturally low tone frequency. Tests show that Celoron gears reduce noise by up to 50% compared to all-metal gear sets!

Made of quality controlled, fabric reinforced phenolic resin, Celoron® high-impact gears are constantly replacing metal in critical areas ranging from earth-moving machinery to compact cars to movie projectors.

Celoron molded materials are only one family of products from industry's largest selection of non-metallic structural and electrical materials . . . including thermosetting laminates, vulcanized fibre, silicone rubber, and mica.

This wide choice gives you every assurance of meeting your exact quality and cost needs in plastic material. Refer to Sweets PD file or write to us for the latest Celoron catalog.

CONTINENTAL-DIAMOND FIBRE

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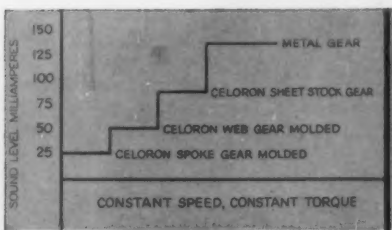
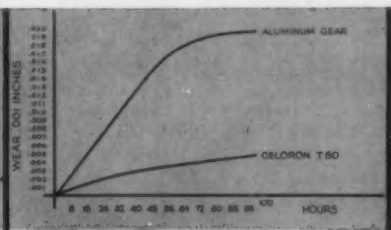
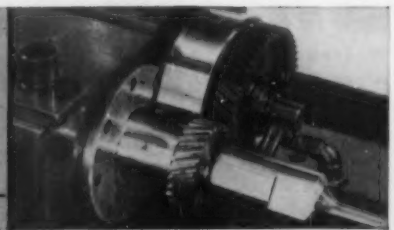
In Canada, 46 Hollinger Road, Toronto 16, Ont.



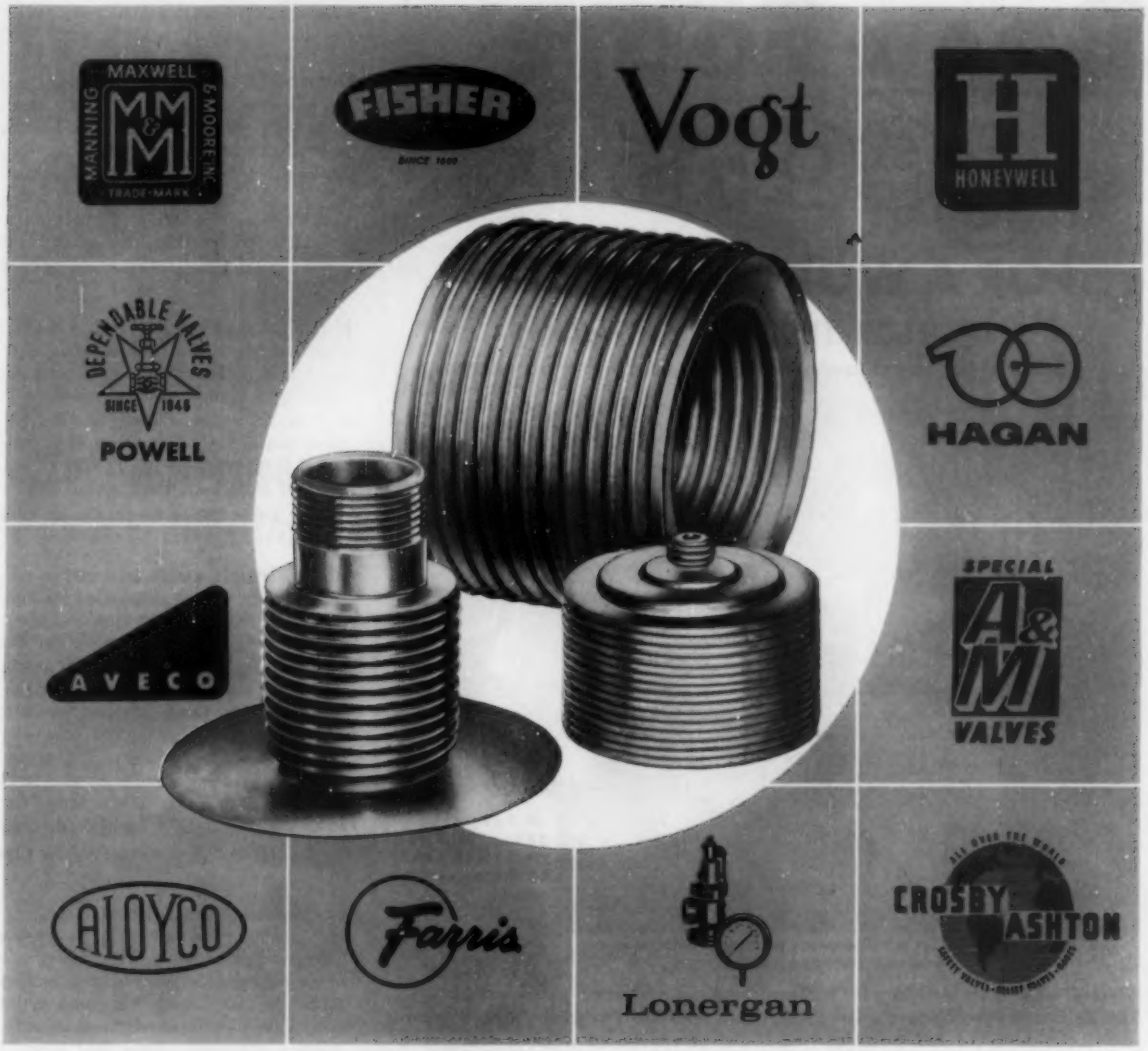
Low sound level of Celoron is shown by this graph which compares metal to the different types of Celoron gears.



Long wearing characteristics of Celoron gears are here contrasted to the shorter life spans of metal-made gears.



Quality control of Celoron gears is assured by special testing machines such as this in CDF laboratories.



The country's leading valve manufacturers select **Flexonics** bellows for reliability and long life

To isolate contaminants, resist corrosion, assure reliable sealing and minimize servicing—leading valve manufacturers are adopting bellows for packless valve stem seals. Experience has proved the reliability and longevity of a bellows for performing this function, and Flexonics is the leading and most experienced supplier of bellows to this industry.

However, valve seals are but one illustration of the growing applications of bellows where high pressures, high temperatures, severe corrosive conditions and other complex problems are involved. Perhaps a bellows can be the answer to your design problem. The Flexonics Application Engineering Staff will be pleased to study your specific problem and make recommendations. Or, if you prefer, write for the Flexonics Bellows Design Guide . . . 20 pages of valuable information.

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Flexonics corporation

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ont.

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BRAD FOOTE gears

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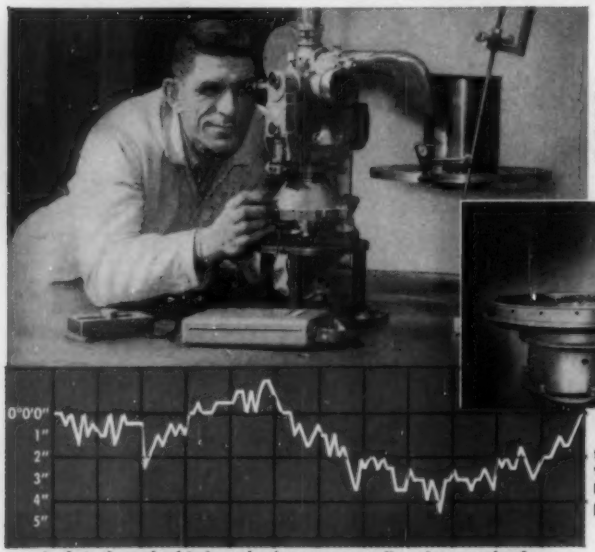
SUPERIOR TESTING METHODS

give you gears cut to maximum accuracy and precision



◀ Theodolite accurate to within 0°-0′-0.2″ of arc being used to check indexing of 154″ gear shaper

▲ Special 154″ gear shaper reworked by BRAD FOOTE for cutting precision gearing

▲ Actual graph of index wheel accuracy readings in seconds of arc at each 3° (rotation) interval

BRAD FOOTE's constant striving for higher quality leaves nothing to chance. Constant checking of all gear-cutting machines assures all gears are cut accurately to the closest possible tolerances.

Here a BRAD FOOTE inspector uses a Theodolite to verify the accuracy of the worm wheel of a large 154″ gear shaper. This instrument is capable of readings accurate to within 0°-0′-0.2″ of arc between adjacent readings.

It is through such painstaking attention to every detail of manufacture... from blanks to finished precision gears... that BRAD FOOTE maintains a rigid standard of excellence which is recognized throughout industry.

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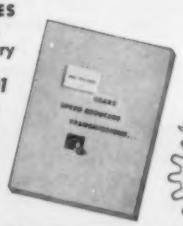
Send for new Bulletin #101 Find out what BRAD FOOTE's two generations of gear building experience can do for YOU. Write today



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subsidiary • PITTSBURGH GEAR COMPANY, Neville Island • Pittsburgh 25, Pa., Phone: SPaulding 1-4600

Direct-lift solenoid valves . . . are full-ported economy valves for operation from zero to 1500 psi. Said to be bubble-tight, leakproof and packless, they are available in bronze or stainless steel in ¼ to 1 in. pipe sizes and for temperatures from −350 to 450 F. Atkomatic Valve Co, 545 W Abbott St, Indianapolis.

Circle 327 on Reader Service Card

High-peel-strength adhesive is for bonding aluminum honeycomb panels, ferrous metals, ceramics and glass. Aluminum-to-aluminum peel strength is 63.3 in.-lb; tensile strength is 3300 psi. Offers pot life of 3-4 days and 45% elongation. 1-qt sample is $6.27. Hysol Corp, Adhesive & Sealants Dept, Olean, NY.

Circle 328 on Reader Service Card

Blueprinting costs are cut . . . by microfilm camera capable of reducing drawings up to 12 ft long down to 35mm microfilm, 4½ in. long. Camera can film such drawings in one exposure at resolution above 100 lines per mm. Half-sizing, as it is used in many industrial plants, is said to provide 75% saving over blue printing in full size. Product of this process provides half-sizing advantages plus additional one-third saving. Delta Blue Print, 5742 Tujunga Ave, N Hollywood, Calif.

Circle 329 on Reader Service Card

Polyester diazo films . . . in black and sepia are usable as working intermediates when making revisions of original drawing, without marring original. Black line film image has good actinic opacity and excellent visual contrast for drawing purposes. Sepia line image is superior for reproduction purposes because of higher actinic opacity. Both are reported to have excellent drawing and reproduction characteristics in addition to long estimated shelf life. 8½ x 11 in. samples are available. Keuffel & Esser Co, 3rd and Adams Sts, Hoboken, NJ.

Circle 330 on Reader Service Card

High-contrast estar-base films offer durability, dimensional stability, high legibility, balanced translucency for fast print-back, excellent drafting surface and moisture resistance for fast drying. Three types provide either same-size positive reproduction without negative step; or positives from paper or film negatives; or enlargements or reductions from film negatives by projection printing process. Films are available in rolls for drawings up to 52 in. wide and in range of sheet sizes. Eastman Kodak Co, Graphic Reproduction Div, Rochester 4, NY.

Circle 331 on Reader Service Card

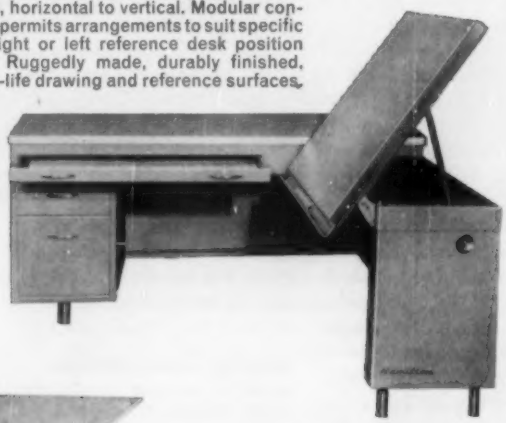
(What's wrong with this picture?)

Is your materials-handling equipment years ahead of your engineering-design equipment?

Materials-handling techniques have made great strides during the past decade—and efficient handling *is* basic to productivity. But *drafting* equipment, too, needs to stay with the times. Are your professional engineer-draftsmen *really* equipped to realize their full potential?

Your draftsmen, your productivity, deserve new Hamilton space-and-time-saving equipment—from Dietzgen

Hamilton L-Contour Table
Sturdy, counterbalanced, drawing surface travels full 20"—permitting frequent position change, greatly reducing fatigue—quickly adjusted to individual requirements for each individual job. Board completely stable in all positions, horizontal to vertical. Modular construction permits arrangements to suit specific needs—right or left reference desk position optional. Ruggedly made, durably finished, with long-life drawing and reference surfaces.



Hamilton CL 100 Series
Side crossrails are eliminated in this entirely new, canted-leg table—yet full stability is achieved. Ample drawer space for reference, tools, and catalogs—many other fine features including Strata-Core board, with green linoleum surface—that tilts 0° to 40°. Beautifully styled Sahara-Tan finish.

In practically all plants, the production cycle *begins* at the drafting board, then is controlled, checked, and qualified by this highly professional function—right up to, and sometimes through, product delivery. Your drafting personnel bring your basic product concepts, product improvements, and plant operating procedures *to life*.

Time and space are raw materials—Hamilton makes the most of them. This drafting equipment keeps working for you—because it is manufactured to rigid specifications, made of highest quality components—and, hour after hour, delivers greater comfort and less fatigue. Because drafting equipment is used by *people*—it must have the flexibility and individuality of use and dimension to fit each person and each job on the board—each individual drafting department problem.

Become familiar with the *entire* Hamilton line. We are at your service, through our experienced planning engineers, to help determine the most productive arrangements for your particular needs.

Hamilton Plan Files
Every tracing becomes a "top sheet"—each instantly accessible—when filed in the Hamilton ten-drawer unit. Individual sections of various types for various filing functions can be assembled in a number of arrangements—and stacked safely to any practical height. Tracing lifting mechanism in each of the ten shallow drawers, for filing of drawings—making each sheet instantly and individually accessible. Exceptionally rugged and durable.

Drafting-Printmaking Booklet reports new techniques for solving engineering and production problems

This new 36 page booklet describes a wide variety of engineering and production problems that have been solved with advance techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2-HK219.
Eugene Dietzgen Co., Chicago 14, Illinois

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The Lisle Magnetic Plug pulls out ferrous metal particles circulating in the fluid.

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DESIGN LITERATURE

The Two Cultures and The Scientific Revolution

C P SNOW. Cambridge University Press, 32 E 57th St, New York 22. 58 pp, 5¼ x 7½. $1.75

Physicist Snow has made significant scientific contributions in his field and has also written a number of absorbing novels about scientists encountering problems much like some of those in the lives of this magazine's readers.

Here is how the British author describes the source of a principal theme in this book: "There have been plenty of days when I have spent the working hours with scientists and then gone off at night with some literary colleagues . . . Moving from one to the other and back again I got occupied with what . . . I long christened to myself as the 'two cultures.' For constantly I felt I was moving in two groups—comparable in intelligence, identical in race, not grossly different in social origin, earning about the same incomes—who had almost ceased to communicate." Later, he goes further, and points out that often there is little more than mutual impatience when scientists and engineers contemplate their respective areas of competence and activity.

Overcoming these shortcomings in communication is a major requisite for today's scientific revolution, which Snow characterizes as "the application of real science to industry, no longer hit or miss, no longer the ideas of odd 'inventors,' but the real stuff." He believes this modern revolution began some 30 or 40 years ago, when the phenomena of atomic particles were first applied to industrial requirements.

The author's analysis of the history of industrial development both in America and in his own country will particularly interest those responsible for design and manufacture today. He points out that the technological problems of factory-based production were solved largely without the aid of engineers, scientists or any other kind of intellectuals. Most of the solutions were discovered and applied by skilled, highly gifted craftsmen, with little or no formal training.

The industrial revolution long since completed in the US, western Europe and the USSR, and also the scientific one he describes, will have to occur simultaneously in the "have-not" nations of Asia, Africa and South America. And, as Snow indicates, today's scientists and engineers know that the big change is technologically possible. The major question is whether this revolution will be led by the scientific and technological forces of the US and its allies or of the USSR.

If this book can contribute to an appreciation of how much the continued well-being of the American engineer depends on raising the technological and productive level of the world's less fortunate peoples, it may well prove the most important book PRODUCT ENGINEERING's subscribers can read this year.—JK

Basics of Gyroscopes (2 vols)

CARL MACHOVER. John F Rider Publisher Inc, 116 W 14th St, NYC. 6 x 9, vol 1, 112 pp; vol 2, 120 pp. $7.75 for set cloth bound.

Cleverly illustrated, simplified survey of the theory of gyroscopes and all its applications. Covers all types of vertical and directional gyros, and describes accessory equipment such as electrolytic pendulous reference and microsyn torquer. Many examples are given of applications such as gyro stabilizer, monorail cars, integrating gyros, and missile controls. Easy reading, yet comprehensive.

Analog Computation

ALBERT S JACKSON. McGraw-Hill Book Co, 330 W 42nd St, NY 36. 6¼ x 9¼, 652 pp. $13.50

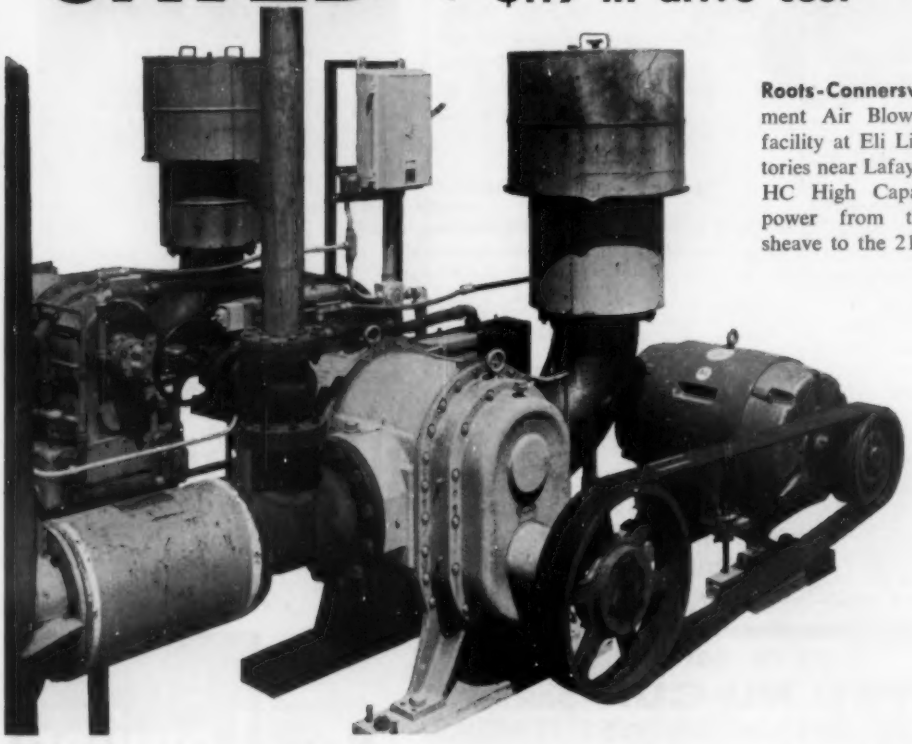
Unlike digital computers, analog machines require the operator to have a working knowledge of electronics if they are to be fully exploited. Despite this limitation, the author of this book has contrived to present the material more from the standpoint of mathematics than electronics. According to the author, little electronics background is required beyond the fundamental level. The only formal prerequisites are a knowledge of calculus and differential equations. For example, Laplace transforms are introduced in chapter 1 and applied throughout the text to present concepts of electrical impedance, transfer functions, feedback control theory.

The first nine chapters discuss the

continued on page 91

Gates High Capacity Drive on Blower for Eli Lilly

SAVED { 6⅞" in face width
97 lbs. in drive weight
$119 in drive cost



Roots-Connersville Positive-Displacement Air Blower on waste-treatment facility at Eli Lilly Company's Laboratories near Lafayette, Indiana. Six Super HC High Capacity V-Belts transmit power from the 13.2-inch DriveR sheave to the 21.2-inch DriveN.

For each blower that Roots-Connersville supplied for the Lilly Laboratories at Lafayette, Indiana, original drive specifications called for 11-groove sheaves using standard belts.

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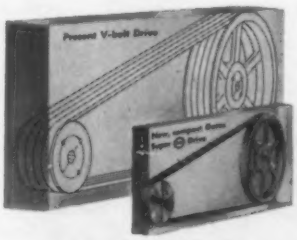
Gates Super High Capacity V-Belts offer similar opportunities to save. These Super HC Drives pack the same hp capacity into smaller space – require fewer belts, smaller sheaves, shorter center distances. The helpful design handbook *"The Modern Way to Design Multiple V-Belt Drives"* is yours for the asking. Just ask your Gates Field Engineer, listed in the Yellow Pages in the nearest industrial center. TPA538A

The Gates Rubber Company, Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario



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ILLUSTRATED: Model No. 2—HOODED

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with **SETKO NU-CUP*** set screws on the job!

Whether it's supporting children on monkey bars or harnessing a spinning shaft you'll find NU-CUP set screws dig in deeper and hold tighter. The shaft illustrated here tells the story.

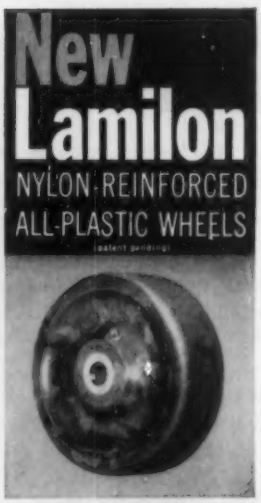
NU-CUP has a 42% sharper point which penetrates in a deep, full circle giving tremendous holding power. In some cases it actually reduces the number of set screws needed for the job. You can get them in slabbed, slotted, hex or fluted socket.

SEND FOR FREE TEST SAMPLES and full information. Ask about NU-CUP set screws. Catalog 23 free, on request.

*U.S Pat No 2,778,265

SETKO Set Screw & Mfg. Co. 153 Main St. Bartlett, Ill. 574

Now one wheel for any section of your plant



Now you standardize on one wheel for all your materials handling equipment. Fairbanks **"Lamilon"** Wheels protect your floors, for they stay smooth and concentric, don't mar or mark. Not affected by oils and greases, **"Lamilon"** Wheels have very high resistance to most chemicals, and have a water absorption factor almost as low as high quality rubber. With their alloy steel roller bearings, hardened steel outer race and provision for pressure lubrication, **"Lamilon"** Wheels roll easier, last longer and give more dependable service than any other plastic wheel.

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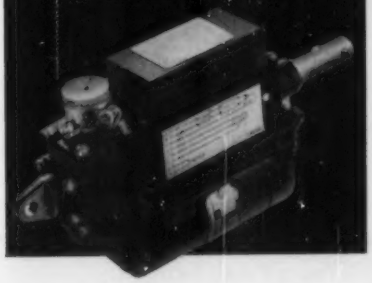
COMPACT AiResearch 60 cycle Actuators *for ground use . . .*



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The above-pictured actuator is used in a ground radar system. It is driven by a single phase 60 cycle ac fractional hp electric motor and can be furnished with a feedback potentiometer for use in servo applications. The entire unit weighs only 2½ lb. and is rated at 200 lb. operating load.

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computer in broad terms and its application to particular classes of mathematical problems: linear differential equations, nonlinear differential equations, simulation, partial differential equations, algebraic matrix models. The last five chapters explore some specific applications and investigate the electronic considerations in analog computer design including a chapter on digital techniques applied to analog computation.

Other Books of Interest

Automatic Data-processing Systems

Robert H Gregory, Richard L VanHorn. Wadsworth Publishing Co Inc, 431 Clay St, San Francisco. 6¼ x 9¼, 705 pp. $11.65

A thorough introduction to the principles and procedures of applying computers to business operations; addressed chiefly to management.

Mobile Manual for Radio Amateurs

American Radio Relay League Inc, West Hartford 7, Conn. 6½ x 9½, 279 pp. $2.50 in US; $3 elsewhere.

An Introduction to Statistical Communication Theory

David Middleton. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6¼ x 9½, 1140 pp. $25.

Discusses application of modern statistical methods to the random phenomena (messages, signals, noise) that influence and control design and operation of communication systems.

ABSTRACTS FROM THE LITERATURE

Rolling Friction of Balls on Plates

Even the extremely small frictional force encountered by rolling balls can be important in certain types of applications, such as instruments. To determine the nature and magnitude of such energy losses, a laboratory study was conducted that developed data on the influences of such factors as load, material and surface roughness. An equation was derived relating rolling force and damping capacity of the ball and plates.

"Rolling Friction of Balls on Plates," R. C. Drutowski, General Motors Engineering Journal, Aug-Sept '60, GM Technical Center, Warren, Mich.

How Organic Compounds Affect Metal Fatigue

The effects of polar and non-polar organic materials such as n-hexadecane, xylene, benzene, octyl alcohol, dodecyl

continued on page 92

No. 18 of a series

Eastman 910 Adhesive solves another production bottleneck

Atkins & Merrill, Inc., industrial model makers, of South Sudbury, Massachusetts, produce quarter-scale cut-away models of the famous Pratt & Whitney J-57 TurboWasp jet aircraft engine.

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Fastening the blades posed a problem, however, as soldering or welding generated excessive heat, causing the blades to warp.

The problem was solved with high-strength Eastman 910 Adhesive. It sets quickly without heat, requires only contact pressure. To date, more than 70,000 blades have been bonded.

Eastman 910 Adhesive is making possible faster, more economical assemblyline operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problems can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9110 Irvin Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. P-10, Kingsport, Tenn. (Not for drug use)
See Sweet's 1960 Prod. Des. File, 7/E

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alcohol, dodecylamine, octadelylamine on the fatigue strength of steel, magnesium, and copper-beryllium alloys were investigated. These compounds apparently form tightly packed monolayers that act as a barrier to water and oxygen molecules.

"Effect of Organic Compounds on Metal Fatigue." National Bureau of Standards, Technical News Bulletin, Aug '60. Single copy, 15¢; order from Superintendent of Documents, US Government Printing Office, Washington 25, DC.

1959 Metalworking Literature

This bibliography of material published during the calendar year 1959 is divided into sections. Reviews of papers on cutting, forming, cutting fluids, grinding are included.

"A Review of Metal-processing Literature," Campbell, Boulger, Smith, Reichenbach et al. Mechanical Engineering Sept '60, 29 W 39th St, New York 18.

Greases for Extreme Conditions

Describes lubricants available for high-temperature and high-speed applications and discusses effects of various thickening and other additives.

"Greases for Extreme Environments," Armstrong, Handschy and Loeffler, Shell Oil Co. NLGI Spokesman, Sept '60, 4638 J C Nichols Parkway, Kansas City 12, Mo.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 97.

STANDARD AND SPECIAL HINGES—Catalog 153, 56 pp. Covers dimensions and specifications of standard or special hinges and hardware. Includes alphabetical and numerical indexes. With illustrations of each hinge type. Braun Mfg Co Inc., 1657 N Kostner Ave, Chicago 39.

Circle 350 on Reader Service Card

INDUSTRIAL HEATERS AND DEVICES—Bulletin GEC-1005K, 48 pp. Revised catalog lists specifications and application information for various industrial electric heaters and devices. Includes heater-control and wiring diagrams, photos and dimensional drawings for most heaters. General Electric Co, Schenectady 5.

Circle 351 on Reader Service Card

PLASTICS—Catalog, 64 pp. Lists available sizes, weights, color ranges, textures, purchasing specifications, grades and

continued on page 94

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There are only four basic numbers in Fenwal's new "500" Line of Electronic Temperature Controllers and Indicators. But they provide industry with a broad choice of instrumentation *not available elsewhere!*

For example, a packaging machine manufacturer might have the problem of controlling 6 heater blocks on a unit capable of sealing a variety of films. He'd want separate control of each block — 3 "ON-OFF" and 3 proportioning — with remote adjustment of control. The Fenwal 536 Controller would give him all this. For indication during periodic checks, he'd simply add the 580 Indicator. *Price? Extremely reasonable!*

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Another manufacturer whose needs are only indication, might select the 582 Thermometer. And there are many *modifications* and *combinations* possible. Why not make *your* choice from these "Smarter Looking Smarter Acting" Fenwal Instruments? Write for Bulletin MC-190. FENWAL INCORPORATED, 32 Pleasant Street, Ashland, Massachusetts.

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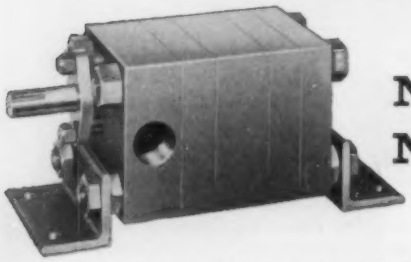

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Northern designs and builds quality into every pump. For each application, materials are selected with infinite care—gears with ground tooth form for perfect contact, correct clearances. Meticulous inspection at every stage in the manufacturing process assures efficient, economical, lasting service for even the most difficult pumping tasks under rugged conditions, indoors and out, year after year.

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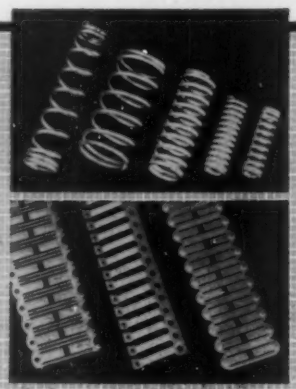

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prices. Includes revised and expanded comparison table of properties of 14 plastics families. Cadillac Plastic & Chemical Co, 15111 2nd Ave, Detroit 3.

Circle 352 on Reader Service Card

TUBE FITTINGS—Catalog 259, 20 pp. Specifications and dimenisonal drawings of tapered or SAE straight-thread fittings. Lenz Co, 3301 Klepinger Rd, Dayton, Ohio.

Circle 353 on Reader Service Card

HIGH-VACUUM GAGES—Bulletin 9-1, 32 pp. Specifications, ranges, features and operating principles of line of vacuum gages. Consolidated Vacuum Corp, 1775 Mt Read Blvd, Rochester 3, NY.

Circle 354 on Reader Service Card

STOCK PERMANENT MAGNETS — Loose-leaf catalog, 52 pp. Presents characteristics of new designs in multiple casts, blocks, bars, solid and hollow cylinders, salient-pole, curved-path and ceramic permanent magnets offered from stock. Applications Research Div, General Magnetic Corp, 10001 Erwin Ave, Detroit 34.

Circle 355 on Reader Service Card

PUMPING AND HYDRAULIC ENGINEERING DATA—Manual EM-77, 20 pp. Covers definitions, formulas, testing, tables, charts and determinations involved in pumping and hydraulic engineering. Peerless Pump, Hydrodynamics Div, 301 West Ave 26, Los Angeles 31.

Circle 356 on Reader Service Card

HONING—Catalog 200, 16 pp. Describes internal, external, and straight-line honing. Explains honing process and shows typical honed parts. Charts list spindle speeds and coolants for various honing operations. Barnes Drill Co, 880 Chestnut St, Rockford, Ill.

Circle 357 on Reader Service Card

INDICATOR LIGHTS — Brochures L-160B and L-163, 8 and 4 pp. Form L-160B discusses ultraminiature indicator lights and their use either singly or in multiples. Form L-163 surveys various available readout indicator lights, illustrated with lifesize photos. Dialight Corp, 60 Stewart Ave, Brooklyn 37, NY.

Circle 358 on Reader Service Card

FLOWMETERS—Catalog C295-1, 8 pp; instrument data sheet 10.3-9, 4 pp. Cover specifications and characteristics of meters using vortex-velocity principle for measuring liquids and gases. Minneapolis-Honeywell Regulator Co, Industrial Div, Wayne and Windrim Aves, Philadelphia 44.

Circle 359 on Reader Service Card

SOLID AND CLAD METALS—Brochure GP-1B, 4th edition, 16 pp. Describes scope of line that includes solid and clad

base and precious metals, thermostat metals, industrial metals and electrical contacts. Texas Instruments Inc, Metals & Controls Div, 34 Forest St, Attleboro, Mass.

Circle 360 on Reader Service Card

BALLSCREW ASSEMBLIES – Bulletin, 8 pp. Outlines ballscrew assemblies, their applications and design-operation characteristics. Walter Kidde & Co Inc, Kidde Aero-Space Div, Belleville 9, NJ.

Circle 361 on Reader Service Card

INSTRUMENTATION TUBING – Bulletin 380, 8 pp. Characteristics, performance information and applications of all types of small-diameter tubing for instrument applications. Superior Tube Co, 1556 Germantown Ave, Norristown, Penna.

Circle 362 on Reader Service Card

POWDERED-METAL STRUCTURAL PARTS—Brochure, 8 pp. Describes products and services of company. Includes mechanical properties chart and page of illustrated design considerations for powdered-metal parts. American Powdered Metals Inc, North Haven, Conn.

Circle 363 on Reader Service Card

VIBRATION, NOISE AND SHOCK ISOLATION—Booklet K4G, 8 pp. Specifications and performance information for 27 types of products for control and measurement of machinery vibration, shock and noise. Discusses relative merits of steel springs and organic materials as isolation media. Includes selector chart. Korfund Co Inc, 19G Cantiague Rd, Westbury, NY.

Circle 364 on Reader Service Card

STOCK RELAYS—Catalog 60-8, 8 pp. Lists hundreds of standard stock relays with diagrams, prices and electrical operating characteristics. Kurman Electric Co, 191 Newel St, Brooklyn 22, NY.

Circle 365 on Reader Service Card

MULTITUBE HEAT EXCHANGERS—Bulletin 111, 8 pp. Explains design features and applications of line of multitube, double-pipe heat exchangers. Cutaway drawings illustrate construction. Brown Fintube Co, 300 Huron St, Elyria, Ohio.

Circle 366 on Reader Service Card

SYNCHRONOUS MOTORS—Folder SE-L2604, 8 pp. Contains characteristics, specifications, ratings and outline dimensions of 50, 150 and 250 in.-oz synchronous motors. Superior Electric Co, Dept SS, Bristol, Conn.

Circle 367 on Reader Service Card

POROUS TEFLON AND KEL-F—Bulletin P-103, 4 pp. Lists standard forms fabricated from these chemically inert fil-

continued on page 97

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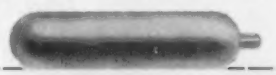

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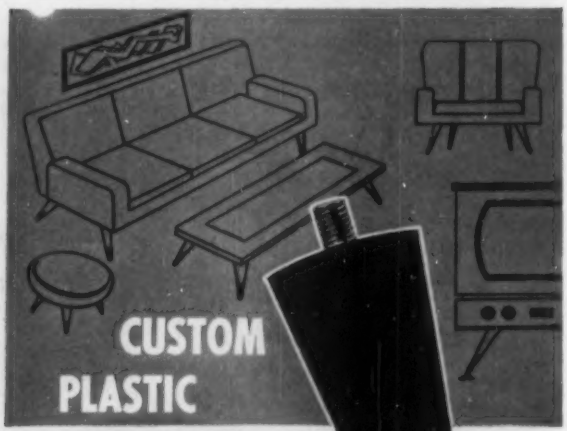

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ter media. Includes specifications of standard materials and prices. Porous Plastic Filter Co Inc, Sub of Pall Corp, 30 Sea Cliff Ave, Glen Cove, NY.

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EPOXY-INSULATED MOTORS—Bulletin PB-6000-12, 4 pp. Describes epoxy-insulated motors up to 500 hp, class B, 140 F rise, random-wound in voltages to 600 and form-wound in voltages to 4160. With illustrations and cutaways. Elliott Co, Jeannette, Penna.

Circle 369 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

PRECISION TEST GAGES—Brochure, 12 pp. Describes calibration and accuracy, Bourdon tube manufacturing techniques, gage features and applications of pressure sensing and indicating units. Seegers Instrument Co, 515 W Main St, Barrington, Ill.

REPRINTS

Reprints currently available without charge are listed on the Reader Service Card bound in this issue. Single copy free; quantity prices on request.

The following special reports are available as long as the supply lasts, from Reader Service Dept., Product Engineering, 330 W 42 St, New York 36. Please enclose remittance with order; we pay postage.

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Combined reprint of 5 steps to faster reading; 8 steps to better writing; 7 steps to better reporting, 24 pp. $1

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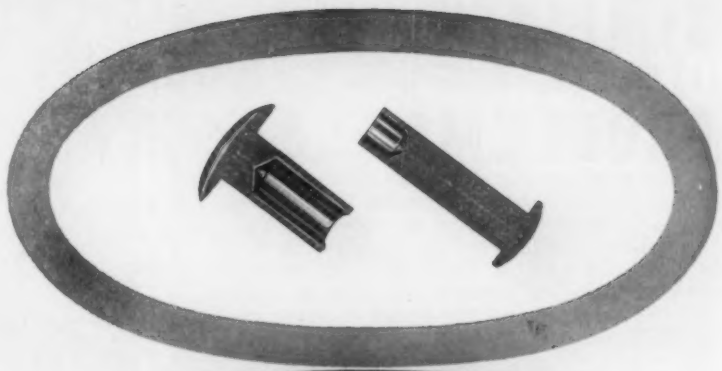

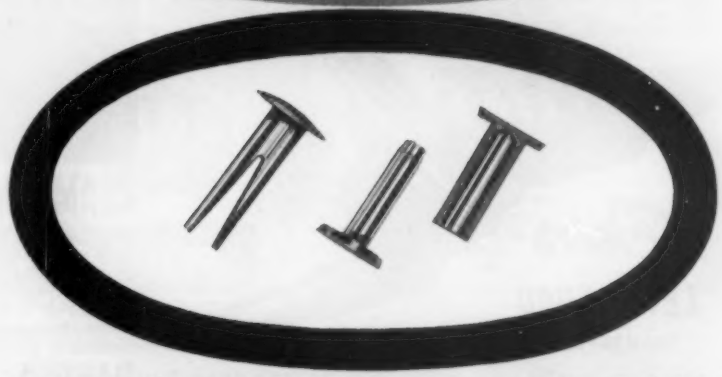

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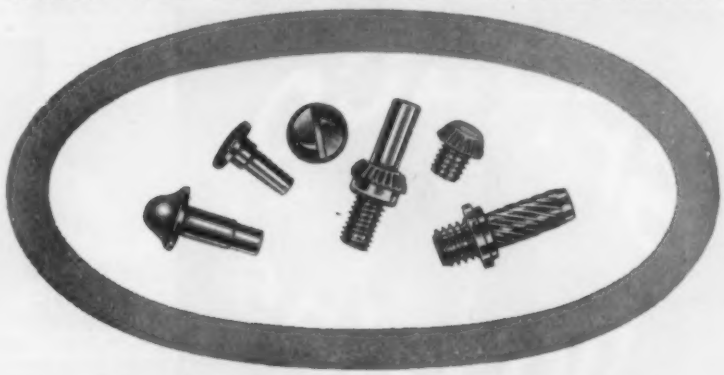

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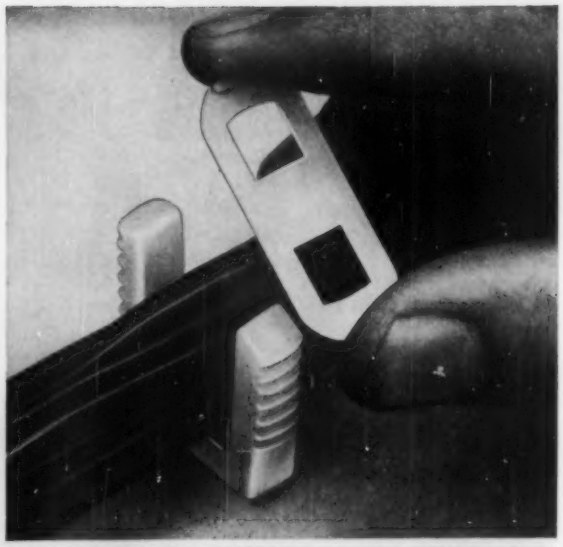

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Study of 50 companies shows changes in large and small companies, 24 pp. 25¢

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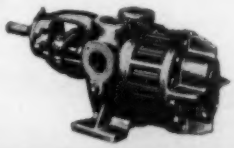

Series F 1 to 300 GPM
Pressures to 300 PSI

Feature helical steel pumping gears, hardened steel shafts, bronze flange-type bearings. 4-port design with 8 optional piping arrangements (4 for CW and 4 for CCW rotation) solves installation problems. With or without built-in relief valve in either mechanical seal or packed box construction.

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Designed to operate at direct motor speeds. Used for all types of hydraulic mechanisms where high pressures are required. Hardened steel spur gears for maximum efficiency, and heavy duty roller bearings and bronze wear plates for long life service. Mechanical seal or packed box.

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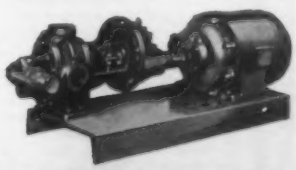

Series 3600 40 to 300 GPM
Pressures to 100 PSI

Handle thick or thin liquids at slow speeds. Operate in either direction. Hardened iron pumping gears, hardened steel shafts, heavy duty bronze sleeve bearings. Mechanical seal or packed box. Series includes tank truck pumps as well as single motor driven units with gear reduction.

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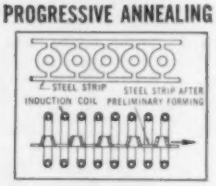
PLASTIC COATING OF TOOL HANDLES

A production line operation for coating handles of tools at Whitney Metal Tool Co., Rockford, Ill. uses induction heating with excellent results. The handles only are heated by induction to the desired temperature then dipped into a vinyl chloride base coating material for a short period depending upon the thickness of coating desired. The plastic coating formed on the handles is then cured by immersion in a carbo-wax bath.

FORMING OF METAL STRIP FACILITATED BY PROGRESSIVE ANNEALING



Metal forming operations which require intermediate anneals to restore ductility can be facilitated by induction annealing the strip progressively. Diagram illustrates this procedure for partially formed thin austenitic stainless steel strip. The induction annealing operation is scheduled in the production line between two press operations. Metal strip and wire of other materials are also induction annealed in this manner.

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. . . a Palmetto® Engineering Report

The generally unrecognized major cause for V-ring failure—and the need for improved adapters—has been identified in a Palmetto research program under way since 1959.

V-packing wear usually shows first as loss of material in the sealing ring farthest from the pressure medium (the ring adjacent to the female adapter). This is followed by progressive failure of the succeeding rings, resulting in breakdown of the set. The pattern is commonly accepted as normal—induced by uneven distribution of pressure through the set, scuffing, or lack of lubrication.

Now Palmetto testing and examination of worn sets show that the major cause of failure is extrusion and resultant "nibbling" loss of material. Portions of the top sealing ring pass through the gap between the female adapter and the surface sealed. Then, as succeeding rings are no longer adequately supported, each in turn is deformed into the space vacated above.

The obvious remedy is to eliminate the extrusion gap around the female adapter—an impossible goal when using previous types of adapter. Rigid metal or phenolic adapters would require zero tolerance production and perfect surface finishes on both the adapters and the surface sealed. Soft adapters have sufficient flexural characteristics to conform to the sealed surface, but lack the resistance to flow which they must have to prevent extrusion and give proper support to the packing set.

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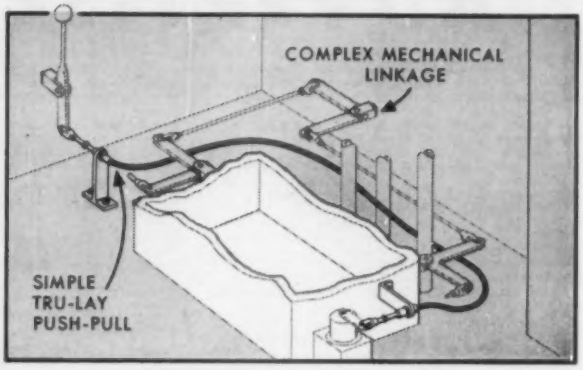

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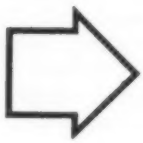

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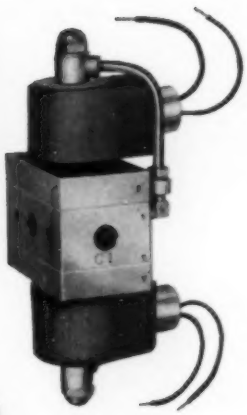

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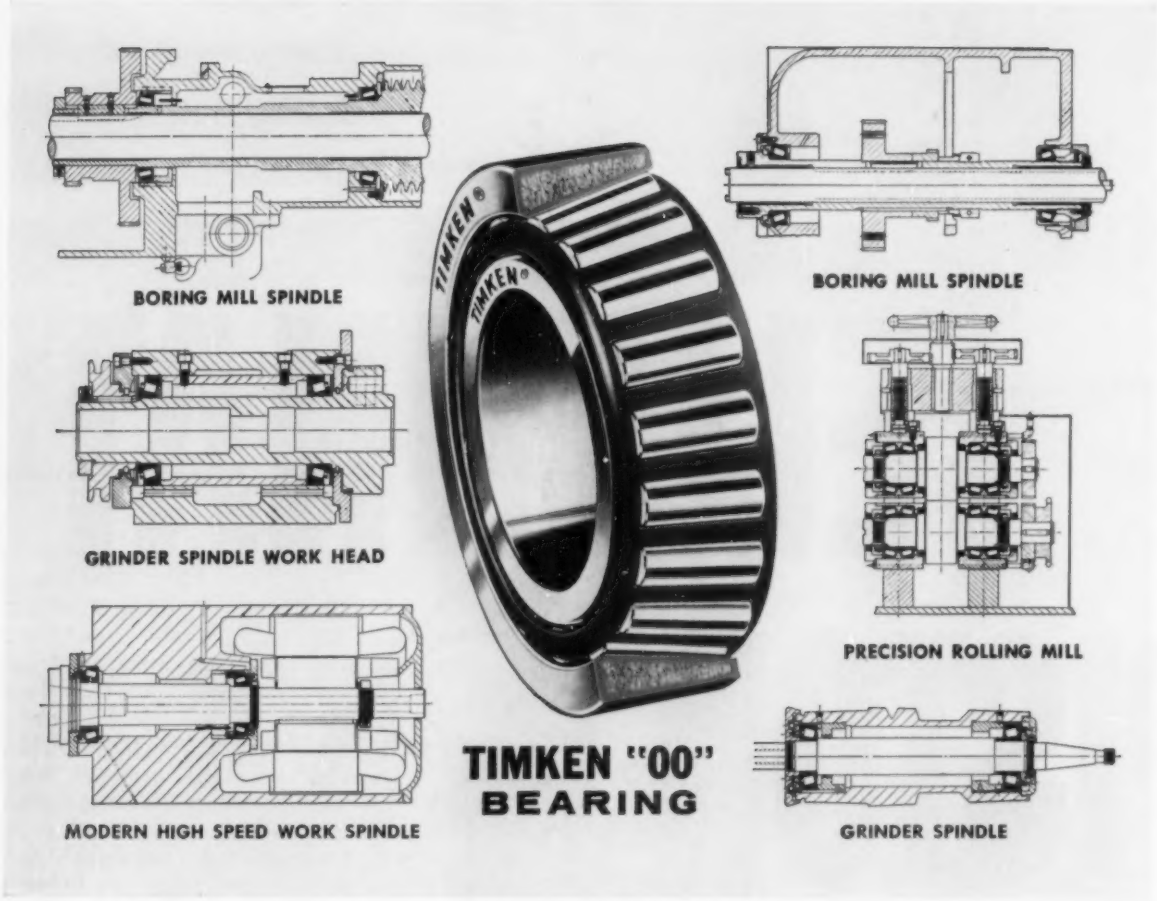

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